(Established 1832).

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY

BY

R. M. VAN ARSDALE

140 NASSAU STREET, NEW YORK

J. S. BONSALL, Business Manager.
F. H. THOMPSON, Eastern Representative

R. V. WRIGHT, } **Editors.**
E. A. AVERILL, }

JULY, 1909

Subscriptions.—*$2.00 a year for the United States and Canada; $2.50 a year to Foreign Countries embraced in the Universal Postal Union.*
Remit by Express Money Order, Draft or Post Office Order.
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Damrell & Upham, 283 Washington St., Boston, Mass.
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MASTER MECHANICS' ASSOCIATION.

FORTY-SECOND ANNUAL CONVENTION.

The convention was called to order at Young's million-dollar pier at Atlantic City on Wednesday morning, June 16, by President H. H Vaughan.

Following a prayer by the Rev. Dr. Caldwell, the president delivered a most excellent address, which is very largely reprinted on page 265 of this issue. The address included some most valuable suggestions for the future work of the association and considered the advisability of the uniting of the M. M. and M. C. B. Associations. The resolutions presented by a committee appointed to consider the suggestions of the president are given later.

The secretary's report showed a total membership of 961, of which 902 were active members. He reported a balance from the yearly financial transactions of $71.50. A legacy of $5,000 from Emma A. Tillotson, deceased, widow of Luther C. Tillotson of New York, to the American Railway Master Mechanics' Association was announced. This has been invested by the executive committee and the interest will be applied to such investigations as they may recommend. The dues for the ensuing year were fixed at $5.00.

Under the head of new business Mr. Seley moved a resolution that a committee be appointed to act with a similar committee of the M. C. B. Association and the Railway Storekeepers' Association to formulate recommendations for standards of the association as to the grading of lumber for railway use. This resolution was carried.

Mr. Crawford requested that a committee be appointed to decide upon what action the association should take in regard to a bill now before the Federal Congress in regard to the inspection of locomotive boilers. The report of this committee will be given later.

OFFICERS.

The officers for the ensuing year were elected as follows: President, G. W. Wildin, N. Y., N. H. & H.; first vice-president, C. E. Fuller, Union Pacific; second vice-president, H. T. Bentley, C. & N. W.; third vice-president, D. F. Crawford, Pennsylvania Lines; treasurer, Angus Sinclair, Railway and Locomotive Engineering. Members of the Executive Committee —C. A. Seley, C., R. I. & P.; D. R. MacBain, N. Y. C. & H. R.; F. M. Whyte, N. Y. C. & H. R., and J. F. Walsh, C. & O.

SUBJECTS.

Committee:—R. Quayle, Chairman; Wm. McIntosh, P. Maher.

The committee, appointed to suggest subjects for committee work for the 1910 convention, reports as follows:

COMMITTEE REPORTS.

1. The importance of shop and operating costs and the best methods of grouping in concise or graphic form for information of officials to whom this information is of vital importance.
2. What are the causes of the reduction in the life of locomotive fire boxes at present as compared with designs of former years?
3. Uniform grading and inspection of lumber for railroad use. (For joint consideration, provided a similar committee is appointed by the Master Car Builders' Association.)
4. Investigation of design of driving-boxes, brasses, shoes, wedges, binders and frames that will give increased mileage to locomotives between shoppings.
5. The operation and maintenance of electric locomotives.
6. How can locomotives be handled by the departments responsible for their movement so as to increase their efficiency? For example, so that four will do the work now requiring five locomotives.
7. Feed-water heaters in locomotive practice.
8. Management and discipline of employees.

INDIVIDUAL PAPERS.

Engineering Experiment Stations, Prof. Lester P. Breckenridge, University of Illinois Experiment Station.

In addition to the report, the subject of "Frame construction for engines with outside valve gear" was also suggested and adopted as part of the report.

The committee (L. G. Parish, F. H. Clark and B. P. Flory) which was appointed to report on the recommendations in the President's address presented the following resolutions, which were adopted by the association:

Resolved, That the executive committee appoint the following:

A committee to report at the next convention upon the heavy articulated locomotive, considering its advantages, disadvantages, possibilities and limitations, from the operating standpoint.

A committee to report at the next convention upon the electric locomotive, considering its advantages, disadvantages, possibilities and limitations, from the operating standpoint.

A committee to report next year a plan whereby the work of the railway clubs and that of the association may be coordinated for the assistance of our committees, for the discussion of subjects in detail in their relations to local conditions, for the educational advantage of minor officials, and for the conservation of time in the conventions of our association; the purpose being to gain for the Master Mechanics' association the assistance of the railway clubs as it is enjoyed by the Master Car Builders' association in connection with local discussions of interchange rules.

That a committee of three members be appointed by the president to confer with a similar committee of the Master Car Builders' association and present for discussion next year a constitution and by-laws of a new association to combine the American Railway Master Mechanics' association and the Master Car Builders' association into a consolidated association, this committee to also report the advantages and disadvantages of such consolidation, considering the question from every standpoint.

A committee to report next year to consider a systematic plan for stating operating costs controlled or influenced by the motive power department, in order to facilitate recommendations as to motive power policy and to render it possible to make intelligent and fair comparisons.

AMENDMENTS TO THE CONSTITUTION.

The report of the committee on "The Revision of the Constitution and By-Laws" was adopted by the association. This provides for two changes in the constitution, both of which refer to the reference of papers on certain subjects to the American Railway Association.

The changes in the by-laws were in connection with the committee reports, which must be in the hands of the secretary not later than April 1 and May 1, depending on the grade of the committee.

MECHANICAL STOKERS.

Committee:—T. Rumney, chairman, D. F. Crawford, C. E. Gossett, F. H. Clark, Geo. Hodgins.

This committee has been advised that further development and extended use of the Victor and Crosby stokers has ceased, and will confine its remarks to the Strouse and Hayden stokers, the remaining two reported upon at the last convention. We have also investigated, as far as possible, all types of mechanical stokers which have reached an interesting state of development, but, with the exception of one stoker, have been unable to procure any figures of tests.

The Strouse overfeed stoker,* as manufactured by The American Automatic Stoker Company, is now said to be at a marketable stage, twenty-two of them having recently been furnished to the Chicago & Alton Railroad for application, and two to the Iowa Central, and it is hoped that in the near future there will be available data covering practicability and efficiency; but as yet we have been unable to procure any data of value on the subject, the tests, apparently, having been more on the order of proving the mechanical possibility of the apparatus and observing the effect on the reduction of black smoke. The Strouse stoker is of the steam-driven horizontal reciprocating plunger

* See AMERICAN ENGINEER, April, 1908, page 151.

type. The coal is fed through a detachable hopper to the plunger distributor, which distributes it in the firebox by the forward movement of the plunger. The firebox door is replaced by a special door hinged at the top and opening inwardly, being operated automatically. In event of resorting to hand firing the suspension rods which support the stoker in position are disconnected, the stoker moved into the gangway and the original fire door reapplied. The stoker successfully handles any grade of coal from slack up to what will pass through a five-inch screen. We are advised that the coal is well distributed and raking is unnecessary.

The Pennsylvania Railroad is developing an underfeed stoker of its own design, which so far seems to give promising results, but there is no data at hand showing its performance. This stoker uses coal up to sizes of four or five-inch cubes, and requires no change of the locomotive other than the application of a special form of grate. The application of the mechanism is such that the fire door is in no way obstructed, so that hand firing may be resorted to on the road without any change or removing of apparatus. At the present time the coal is shoveled from the tank to the hopper of the stoker, but it is intended to install some means of mechanical conveyance.

The Barnum underfeed stoker, of the Chicago, Burlington & Quincy Railroad, requires screenings of one and one-half inches. The application of this stoker is such that hand firing cannot be accomplished without changes such as to require the work to be done in the shop. The installation of the stoker necessitates the removal of the grates, extension of the back frames, and the remodeling of the ash pan and draft appliance in the front end. The distribution of coal in the firebox is such as to seldom necessitate raking of the fire. With this stoker also the coal is delivered to the hopper by hand, but it is the intention to make this automatic later.

The "Black" or "Dodge" stoker, which is being developed on the Erie Railroad, is of the overfeed type. The only change to the locomotive necessary to the application of this stoker is the replacing of the firebox door by a specially designed box-shaped door, in the center of which is a pivoted shelf which can be tilted to any angle to the plane of the fire by means of a lever at the front of the door. Two four-blade gears revolving at about two hundred and fifty revolutions per minute on the top of the shelf spray the coal over the fire as it falls on the shelf from the hopper, which hopper is attached to the top of the door and forms a part thereof. The distribution of the coal is controlled by means of tilting the shelf and thus directing the spray of coal to any desired part of the grate. The whole operation can be observed through peep holes in the fire door. The coal is conveyed to the hopper by a worm conveyor extending from the forward end of coal space in the tank to the hopper, coal being delivered to this worm from the full length of the coal space by means of another worm. In order to fire by hand, the front worm conveyor is thrown back on its hinge and secured to the tank; the door requires no change, being all in one piece and hinged on the original fire-door hangers and can be operated similarly to the ordinary door. The size of coal for which this stoker is adapted is everything that will pass through a three or four-inch screen.

The Hayden automatic stoker,† in use on the Erie Railroad, was fully described in the Proceedings of 1908. A number of tests have been made of this stoker. While the results of the tests were not favorable to the stoker, its possibilities were felt to be such as to warrant the construction and placing in service of five additional ones. It is evident that the operation of the stoker will be best shown by comparison of the equivalent evaporation per pound of combustible and the combustible-hours per ton-mile, which latter item takes into consideration the time in which the run is accomplished. Engine 1627 (cyl. 22 x 32 in., 62 in. drivers and 200 lbs. steam), which made the first test in April, 1907, showed .734 per cent. more equivalent evaporation per pound of combustible with the stoker, while engine 1653 (same class) in the second test, made in April, 1908, showed 11.16 per cent. less. The fuel used with engine 1627 was run-of-mine, the lumps being broken to about three-inch size by the fireman, to suit stoker requirements; whereas engine 1653 was furnished with coal passed through a three-inch screen, resulting in the latter containing a very large proportion of fine coal, which would affect the evaporation per pound of combustible. While the combustible hours per ton-mile takes in, to a certain extent, all the varying conditions which make it impossible to obtain two similar results of like tests, it is of fairly good comparative value. With engine 1627, the stoker showed a loss of 17.02 per cent., while with engine 1653 the combustible-hours per ton-mile were only 8.7 per cent. greater with the stoker.

It was realized that although the stoker might show an increase in fuel consumed per ton-mile, as the provision of automatic firing would induce the engineer to work the engine harder since the firemen's labor and endurance were not concerned, it was felt that the time on road would thus be reduced and economy shown in fuel-hours per ton-mile when used as a basis of comparison, but the results were not as anticipated.

† See American Engineer, April, 1908, page 147.

The committee directs attention to the fact that automatic stokers are in their infancy, and it should be realized that efficiency over hand firing could hardly be expected at such an early stage.

The gradual retirement of old cars with structural weaknesses, and the advent of improved draft gears and triple valves, render it possible to increase the train length without resultant troubles from trains parting; consequently it is reasonable to assume that the average tractive power of locomotives will increase. It is possible, therefore, that the increased fuel consumed per mile will render it advisable to provide mechanical means for firing locomotives in order that they may develop a high sustained tractive effort, and render the service attractive to men who possess qualifications to become successful locomotive engineers.

A successful automatic stoker should render locomotive firing more attractive, raise the standard of the service, permit close attention to economic handling of fuel and reduction of black smoke, enable firemen to become better acquainted with the general duties of a locomotive engineer, and reduce tube and firebox troubles.

Discussion.—Mr. Nelson (P. R. R.) called attention to the fact that the term "fuel hours per ton mile" probably meant fuel per ton mile.

Mr. Henderson presented a detailed estimate of the probable advantage of a mechanical stoker on a larger Mallet locomotive, as follows:

"The division to be covered by this locomotive was 100 miles in length, against the traffic, of which there is a 0.5 per cent. compensated up-grade 40 miles long, and the remaining 60 miles are practically all down-grade. The locomotive upon which our figures were based was of the Mallet type, having a tractive force of 65,000 lbs., which would enable it to haul at slow speeds 4,200 tons up the 0.5 per cent. grade, on which our figures were made, ascending the grade at 6, 10 and 15 miles per hour. It was assumed that one fireman could handle 3,000 to 4,000 lbs. per hour throughout the 40 miles up-grade, or that two men, by working in relays, would be needed to supply 6,000 to 8,000 lbs. an hour, but for quantities over this a mechanical stoker would be necessary. As the grate area of this locomotive is 78 sq. ft., it will be seen at once that it would be possible to burn from 12,000 to 15,000 lbs. of coal per hour if found desirable or necessary. In making these figures, the following units were assumed: The actual time between terminals would be 20 per cent. greater than the running time, this allowing for lay-overs, etc.; the down-hill speed would be 30 miles an hour; the cost of the coal was taken at $1 per ton and of water at 5 cents per thousand gallons. Allowances were also made for repairs, renewals, pay of enginemen, handling at terminals and interest on investment. It was considered that there would be 5 hours consumed in turning the engine at the terminals of the division, and the cost of train supplies, car repairs, pay of trainmen, etc., were included, so that the figures show the actual cost of operating the train, but, of course, do not cover the general expenses of superintendence, maintenance of track, buildings, bridges and other data except the usual train operation, which figures really comprise only about 40 per cent. of the total cost due to all expenditures of the road. The cost was figured out for the total movement on one trip, also for 1,000 ton miles of train back of engine, including the weight of the cars and ton miles per hour performed by the engine, with the allowance of five hours for turning, as above mentioned. These figures, therefore, enable one to see at a glance the variation in cost and capacity due to one or two firemen, or to a mechanical stoker. The figures are given below:

Speed, up hill, m. p. h.	6	10	10	15	15	15
Cost, movement, per trip	$79.93	$82.35	$62.18	$87.05	$67.00	$50.38
Cost, per 1,000 ton-miles	.19	.20	.21	.22	.22	.25
Ton-miles, per hour	27,300	34,400	24,600	38,000	28,300	19,000
Weight of train, tons*	4,200	4,200	3,000	4,000	3,000	2,000
Method of firing	1 fireman.	2 firemen.	1 fireman.	Stoker	2 firemen.	1 fireman.

* Train back of tender.

"It is seen, therefore, that by far the greatest amount of work done by the engine is with the use of a stoker and running up hill at a speed of 15 miles per hour, the assumption being in this case that there would be 15,000 lbs. of coal burned per hour, while running up the grade. The cost per 1,000-ton miles is less than if we attempted to run with half the load at the same speed up hill with only one fireman, and it is only 3 cents greater than if we went up the hill at six miles an hour with a single fireman. At ten miles an hour two firemen would give nearly the same capacity of the locomotive and at somewhat lower cost, but it is rather uncertain whether two firemen can be managed satisfactorily on a locomotive, and where a large amount of traffic is to be gotten over the road, the advantage of being able to push the engine to its full capacity and at a fairly high speed is shown without any uncertainty.

"At 15 miles an hour, considered economical speed for gen-

eral operation, one fireman could handle 19,000-ton miles at a cost of 25 cents, two firemen 28,000-ton miles at a cost of 22 cents, and the stoker 38,000-ton miles per hour at a cost of 22 cents. You will see, with a slight additional increase of cost of stoker over one man at slow speeds, a much larger amount of ton-miles can be obtained, and at speeds of 15 miles an hour the cost of the stoker is considerably less than that of one fireman, and double the amount of ton mileage can be made with the engine."

Mr. Maher (C. & A.) stated that in the case of the first stoker applied on his road, it was necessary to remove it almost immediately, and it was set up in connection with a temporary fire box in the power house and worked for almost a week, giving the men an opportunity to become acquainted with its operation. Following this it was put back on the locomotive and has been in constant use for about sixty days and is still working. This road has twelve engines now equipped and will have a total of twenty within a short time. The troubles up to this time have been but minor. Some runs made by a consolidation locomotive with 22 x 30 in. cylinders and by a Pacific type locomotive, with 23 x 28 in. cylinders, were mentioned as being the most satisfactory. Mr. Maher did not believe that the stoker would reduce smoke to any great extent. In reply to questions by different members he stated that they were not using a brick arch and that the Strouse stoker would give a uniform depth of fire over the whole box, but that the coal could be placed at almost any desired point at any time. They had not had any trouble in connection with the fire box filling up with clinkers or ashes.

D. R. MacBain (N. Y. C.) told of his observations on a consolidation locomotive with a stoker on the Alton. At the end of a 122-mile trip, made in six hours and seventeen minutes, during which time about 20 tons of coal was burned, he found the fire to be clean and in good shape to start out again immediately.

Mr. Gossett (Ill. Cent.) recounted a recent trip he made on a locomotive equipped with a Strouse stoker on the Alton. In this case the train weighed 3,300 tons or 500 tons more than the rating, and averaged 17 miles per hour for 88 miles. The steam pressure did not vary four lbs. during this time and the fireman was able to work leisurely. He expressed himself as being convinced that the stoker had passed the experimental stage, so far as principle is concerned. Mr. Tonge (M. & St. L.) was present on the same trip and agreed with all that Mr. Gossett had said. He also stated that the stoker had not required repairs of any kind for a month.

D. F. Crawford (P. R. R.) stated that he was experimenting with an underfeed type of stoker with some success. This stoker gave a decided reduction in the amount of smoke. The Chicago, Burlington & Quincy Railroad is also experimenting with a similar type of stoker. It is the intention to put an engine equipped with the P. R. R. stoker on the testing plant at Altoona, as well as some other designs, as the opportunity offers. The results of these tests will probably be reported to the Association next year.

REVISION OF STANDARDS.

Committee:—W. H. V. Rosing, chairman; T. W. Demarest, C. B. Young, E. T. White, G. W. Wildin.

The committee called attention to several errors in the 1908 Proceedings. It also recommended that the vertical clearance between the side lugs of the journal bearing and the journal bearing wedge for standard 4¼ by 8 in. and 5 by 9 in. journals be increased to ⅛ in., as with the rough castings used in these articles the present allowance of 1/16 in. is scarcely sufficient to satisfactorily overcome the irregularities of manufacture. Attention was also called to the fact that ⅛-in. clearance was heretofore adopted for the 3¾ by 7 in. and 5½ by 10 in. bearings and wedges, and it should be the same for the 4¼ by 8 in. and the 5 by 9 in. bearings and wedges.

There are a number of gauges now in use for measuring sheet metals based on a numerical system, for which there is no check gauge. The thickness of sheets ordered by the Master Mechanics' standard decimal gauge can always be checked by a micrometer caliper, so there should be no practical opportunity for error or misunderstanding, and the committee urges the early adoption by all of the members of the Master Mechanics' standard decimal gauge in ordering sheet metals.

It was also recommended that committees be appointed for the ensuing year to report on the following subjects:

1. Safety appliances for locomotives—this to include grab-irons, steps, handholds, uncoupling levers, etc., for engine and tender in both yard and road service. As legislation in some States is inclined in this direction, we believe that the Association should take the initiative to furnish a guide for future legislation that will tend to secure uniformity.

2. To revise the present instructions relating to air-brake and train air signals, to meet the requirements of the recent improved developments in air-brake construction and practice, for both locomotives and trains.

Discussion.—On a motion by Mr. Wildin a recommendation to change the clearance from 1-16 to ⅛ in. was to be taken up with the executive committee of the M. C. B. Association, with the recommendation that the change be adopted.

After some discussion in regard to the standard gauge for sheets and wire it was decided to appoint a committee to meet a similar committee of the American Steel Manufacturers' Association and thoroughly discuss the subject.

The other recommendations of the committee were referred to the executive committee for further consideration.

SUPERHEATERS.

The report of the committee on superheaters stated that previous papers before the association had recited the history of superheating thoroughly, and that practical demonstrations had not yet reached a point where sufficient information of definite value can be obtained to warrant the committee making their report at this time.

Upon presentation of this report Mr. Seley submitted some information obtained since the superheater committee report was printed, which gives the results of some passenger engine tests made in the Illinois Division of the C. R. I. & P. Ry.

This division is 181.2 miles between terminals, with no heavy grades or curves.

The trains were Nos. 11 and 6. The average total time was 4 hrs. 24 min., and the average running time, 4 hrs. 9 min. The average number of stops was 7, and the average speed, actual running time, 43.7 m.p.h. The average number of cars in trains was 7.58 and the average weight of trains 425 tons.

The coal was sacked and weighed and the water measured by tank calibration and three round trips run with each engine. There were five engines tested, two with superheaters and three non-superheater simple engines. The performance is shown in the following table:

Ref.	Eng. No.	Kind of Engine.	Mileage Before Test.	Lbs. Water Per Ton Mile.	% of No. 4.	Lbs. Dry Coal Per Ton Mile.	% of No. 4.
1	1019	Atl. Sup.	62,347	1.36	84.	.1816	99.4
2	847	Pac. Sup.	35,504	1.37	84.5	.1655	90.6
3	1013	Atl. Non-Sup.	5,260	1.53	94.4	.1926	100.5
4	863	Pac. Non-Sup.	New	1.62	100.	.1826	100.
5	833	Pac. Non-Sup.	77,281	1.774	109.5	.2309	126.

Test engine No. 4 gave a practically perfect performance and, for the purpose of comparison with the other engines, was taken as 100 per cent. Test engine No. 1 had made 62,347 miles before the test was made. Its performance was 1.36 lbs. of water per ton-mile, or 84 per cent. of the performance of the base engine. Due to the poor condition of its boiler, on account of the time it had been running, the performance in coal was 0.1816, or 99.4 per cent. of the base engine performance. Test engine No. 2 had made 35,504 miles before the test. Its record was 1.37 lbs. of water per ton-mile, or only 0.01 of a pound difference from the first engine, and its percentage of base engine was 84.5. Its coal performance was 0.1655 lbs. of dry coal per ton-mile and 90.6 per cent. of the performance of the base engine. No. 3 had only made 5,260 miles and was in very good condition. The pounds of water per ton-mile were 1.53, or 94.4 per cent. of the base engine. I consider the explanation of this is that the engine was somewhat better suited to the weight of the train than the base engine. The performance of this engine in coal was 0.1926, or 100.5 per cent. of the base engine. No. 5 was a shop candidate, and in fact went to the shop directly after the test, having made 77,281 miles. Her performance in water was 1.774, or 109.5 per cent. of the base engine. The pounds of dry coal per ton-mile was 0.2309, or 126 per cent. of the base engine.

The two superheater engines, notwithstanding the fact that they had made respectively 62,347 and 35,504 miles before the test, did their work with 16 per cent. less water than a new non-superheater engine. The coal performance is not so good

as the water, as would naturally be the case in comparing the performance of a new clean boiler and one after 62,000 miles' service, so that No. 1 shows but a trifle of advantage, but No. 2 nearly 10 per cent., which in connection with the 15.5 per cent. water economy is certainly a fine performance.

The low record of No. 5, aside from its general condition, is no doubt partly due to having a different proportion of cylinders and smaller wheels than on engine No. 4.

The fine performance of engine No. 3 is no doubt due to its proportions being very well adapted to the weight of train and character of road, while no doubt engine No. 4 could have taken a heavier train with as good or better results, these engines being designed for heavier service than the trains on which tests were made.

Some of the dimensions of the engines tested are given in the following table:

No.	Cylinders.	Drivers.	Steam pressure.	Grate area.	Total weight, engine and tender loaded.	Tractive power.
1	21 x 26	73	185	44.86	335,300	24,700
2	22 x 26	69	190	44.86	366,000	31,000
3	21 x 26	73	185	44.86	330,300	24,700
4	23 x 28	73	185	45.00	376,000	31,600
5	22 x 26	69	190	44.86	362,000	31,000

The Rock Island superheater engines were acquired in 1905 and put in service to ascertain their ability to do business without causing train delays or unduly increasing maintenance expense due to the superheater features. It was felt that these were matters of detail that should be worked out before any records or tests for economies were necessary or advisable. We had a number of difficulties of one kind and another, but through them all the advantages due to the superheater features were sufficiently apparent to warrant the effort to overcome them, which we have now done in large measure and feel confident that the showing here made is an honest, consistent one.

LOCOMOTIVE PERFORMANCE UNDER SATURATED AND SUPERHEATED STEAM.

W. F. M. Goss.

[One of the most valuable contributions before the association was Dr. Goss' paper on the above subject, which, in his absence, was admirably presented, in abstract, by Prof. E. C. Schmidt.

This paper was presented together with the report of the superheating committee and was discussed at the same time as that report. It is altogether too voluminous for complete reprinting and only its more general features and conclusions are given below.]

The Origin of the Work.—Under the patronage of the Carnegie Institution of Washington, there have been completed, at the laboratory of Purdue University, two elaborate series of locomotive tests. The first had for its purpose the determination of the performance of a locomotive using saturated steam; the second, that of a locomotive using superheated steam. A description of the methods and results of the first series has been published by the Carnegie Institution,* and a similar description of the second series is now in preparation for publication.† The facts presented herewith are drawn from the more elaborate presentation of these two sources.

The Equipment.—The locomotive upon which the tests were made is that regularly employed in the laboratory of Purdue University. As used in the tests involving saturated steam, it was known as Schenectady No. 2, and since its reconstruction with a superheater, it has been known as Schenectady No. 3. The superheater was made and installed by the American Locomotive Works at Schenectady, and is of the Cole type.

The principal characteristics of Schenectady No. 2 (saturated steam) are as follows:

Type	4-4-0
Total weight (pounds)	109,000
Weight on four drivers (pounds)	61,000
Driving-axle journals:	
Diameter (inches)	7½
Length (inches)	8½
Drivers, diameter front tire (inches)	69.25
Valves—Type, Richardson balanced:	
Maximum travel (inches)	6
Outside lap (inches)	1⅛
Inside lap (inches)	0
Ports:	
Length (inches)	12
Width of steam port (inches)	1.5
Width of exhaust port (inches)	3
Total wheel base (feet)	23
Rigid wheel base (feet)	8.5
Cylinders:	
Diameter (inches)	16
Stroke (inches)	24
Boiler (style, extended wagon-top):	
Diameter of front end (inches)	52
Number of tubes	200
Gage of tubes	12
Diameter of tube (inches)	2
Length of tube (feet)	11.5
Length of fire box (inches)	72.06
Width of fire box (inches)	34.25
Depth of fire box (inches)	79.00
Heating surface in fire box (square feet)	126
Heating surface in tubes (square feet)	1,196
Total heating surface (square feet)	1,322
Grate area (square feet)	17
Thickness of crown sheet (inches)	7/16
Thickness of tube sheet (inches)	9/16
Thickness of side and back sheet (inches)	⅜
Diameter of stay bolts (inches)	1
Diameter of radial stays (inches)	1⅛

The locomotive Schenectady No. 3 (superheated steam) is different from its predecessor, just described, only in so far as changes were necessary in the process of applying a superheater. The Cole superheater consists chiefly of a series of return tubes extending inside of certain of the flues which make up a portion of the water-heating surface. To give room for these superheater tubes, the upper central portion of the usual flue space is taken up by sixteen 5-inch flues, within each of which there is an upper and lower line of superheating tubes. Each loop of the superheater tubes extends from a header in the smoke box, back into its flue to a point near the back tube sheet, where it meets and is screwed into a return bend fitting of special design. From the second of the two openings in this fitting a similar pipe extends forward through the flue and into the smoke box to the header which opens into the branch pipes leading to the cylinders. Altogether there are thirty-two of these loops. The construction of the tee-head and of the four branch headers is such that all steam passing the throttle of the locomotive must pass some one of the several loops.

The characteristics of Schenectady No. 3, so far as these were changed from those of Schenectady No. 2, are as follows:

Number of 2-inch flues	111
Number of 5-inch flues	16
Length of flues	11.5
Heating surface in flues (square feet)	897
Heating surface in fire box (square feet)	126
Total water-heating surface (square feet)	1,023
Outside diameter of superheater tubes (inches)	1¼
Number of loops	32
Average length of pipe per loop (feet)	17,27
Total superheating surface based on outside surface of tubes, neglecting surface of headers (square feet)	193
Total water-heating and superheating surface (square feet)	1,216

Tests With Saturated Steam.

The Tests Under Saturated Steam, the results of which are summarized in table IV, include a series of runs for which the average pressure was, respectively, 240, 220, 200, 180, 160 and 120 pounds, a range which extends far below and well above pressures which are common in present practice. All tests were run under a wide-open throttle. The tests of each series are sufficiently numerous to define completely the performance of the engine operating under a number of different speeds and when using steam in the cylinders under several degrees of expansion.

The first of these tests was run February 15, 1904, and the last August 7, 1905. A registering counter attached to the locomotive showed that between these dates the locomotive drivers made 3,113,333 revolutions, which is equivalent to 14,072 miles.

The Performance of the Boiler.—The fuel which was regarded as standard for these tests was Youghiogheny lump, an average analysis of which, based on air-dried samples, is as follows:

Moisture	.87
Volatile matter	34.10
Fixed carbon	57.62
Ash	7.41
Heating value per pound of dry coal (B. T. U.)	14,295
Heating value per pound of combustible (B. T. U.)	15,585

The pounds of water evaporated per pound of coal, in terms of rate of evaporation, are given in the following table:

Boiler Pressure.	Equations.
240 pounds	$E = 11.040 - .221\ H$
220 pounds	$E = 11.040 - .221\ H$
200 pounds	$E = 11.373 - .221\ H$
160 pounds	$E = 11.469 - .221\ H$
120 pounds	$E = 11.357 - .221\ H$

Where E is the number of pounds of water evaporated from and at 212° F. per pound of coal and H is the number of pounds of water evaporated from and at 212° per sq. ft. of heating surface per hour. The area of heating surface employed is based upon the interior surface of the fire box and the exterior surface of the tubes.

The results show that the lowest efficiency is obtained with the highest pressure. They do not show that the highest efficiency results from the use of the lowest pressure. With one exception, however, the lines representing performance

* "High Steam Pressures in Locomotive Service," published by the Carnegie Institution, Washington, D. C. See also American Engineer and Railroad Journal, Jan., 1907, p. 13.

† "Superheated Steam in Locomotive Service," the Carnegie Institution, Washington, D. C.

TABLE IV.

A SUMMARY OF OBSERVED AND CALCULATED DATA.

LOCOMOTIVE SCHENECTADY NO. 2. (SATURATED STEAM.)

Designation of Tests.													
Number.	Laboratory Symbol.	Speed, Miles per Hour.	Dry Coal per Square Foot of Grate Surface per Hour, Pounds.	Smoke-box Temperature, Degrees F.	Equivalent Evaporation per Sq. Ft. of Heating Surface per Hour, Pounds.	Equivalent Evaporation per Pound of Dry Coal.	Cut-off, Per Cent of Stroke.	Mean Effective Pressure, Pounds per Square Inch.	Indicated Horse-power.	Pounds of Steam per Indicated Horse-power Hour.	Pounds of Coal per Indicated Horse-power Hour.	Draw-bar Pull, Pounds.	Draw-bar Horse-power.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	20-2-240	19.4	55.2	.....	6.68	9.40	14.18	60.19	276.5	26.29	3.40	6,990	242.4
1a	20-2-240	20.0	57.4	635	6.90	9.40	.....	55.53	262.6	.....	.....	.....	.....
2	20-4-240	20.1	76.2	743	9.15	9.32	19.02	82.67	392.5	25.33	3.30	6,690	357.6
3	20-6-240	19.9	.....	745	10.31	.....	26.05	99.05	466.8	24.09	.....	7,626	405.0
3a	20-6-240	19.8	97.3	730	10.76	8.60	.....	95.72	449.3	.....	.....	.....	.....
4	20-8-240	19.9	.....	.....	.....	.....	32.88	120.50	568.0	.....	.....	.....	.....
5	30-2-240	30.0	72.0	.....	8.64	9.33	16.04	52.29	371.3	25.48	3.29	4,554	364.0
5a	30-2-240	30.8	93.9	698	9.75	8.08	.....	51.30	363.0	.....	.....	.....	.....
6	30-4-240	30.0	.....	759	10.52	.....	19.70	66.36	470.6	24.43	.....	4,897	391.1
7	30-6-240	27.5	.....	.....	.....	.....	25.15	83.12	540.3	.....	.....	.....	.....
8	40-2-240	40.0	82.6	809	9.35	8.79	15.24	44.64	421.8	24.16	3.33	3,370	358.5
9	40-4-240	40.0	.....	.....	12.39	.....	20.75	60.06	566.3	23.86	.....	4,259	453.5
10	40-6-240	42.5	.....	.....	.....	.....	27.82	67.17	675.6	.....	.....	.....	.....
11	50-2-240	51.0	85.8	.....	10.57	9.57	15.15	38.59	465.5	24.97	3.07	2,979	404.7
12	50-4-240	50.0	.....	.....	.....	.....	21.12	53.70	635.5	.....	.....	.....	.....
13	20-2-220	19.9	49.0	682	6.72	10.65	14.44	54.27	255.3	27.65	3.24	4,431	234.7
14	20-4-220	20.0	64.0	703	8.23	10.00	19.52	72.39	342.8	25.80	3.18	.....	.....
15	20-6-220	20.0	92.0	764	10.29	8.69	26.98	91.23	431.4	25.51	3.62	.....	.....
16	20-8-220	20.1	122.2	806	12.70	8.08	35.28	111.92	533.0	25.86	3.89	9,190	491.6
17	30-2-220	30.0	64.3	.....	8.00	9.75	13.45	45.15	320.3	26.60	3.41	3,360	268.4
18	30-4-220	30.0	86.5	743	9.75	8.77	21.14	62.88	446.5	24.23	3.29	4,764	380.9
19	30-6-220	30.0	109.9	813	12.01	8.49	26.41	78.89	559.5	23.59	3.34	6,239	499.1
20	30-8-220	31.2	.....	.....	.....	.....	35.87	96.94	715.3	.....	.....	.....	.....
21	40-2-220	40.1	71.5	716	8.77	9.54	14.38	39.16	371.5	25.58	3.27	2,927	313.0
22	40-4-220	40.0	94.3	786	10.95	9.03	20.45	53.81	509.1	23.68	3.15	3,963	406.2
23	40-6-220	40.2	.....	.....	.....	.....	29.82	70.60	672.7	.....	.....	.....	.....
24	50-2-220	40.0	76.9	728	9.18	9.29	14.51	32.04	378.8	26.29	3.45	2,255	300.2
25	50-4-220	40.0	118.2	810	12.25	8.06	21.15	47.56	562.3	24.08	3.57	3,617	481.6
26	50-6-220	50.0	.....	.....	.....	.....	32.57	61.85	732.4	.....	.....	.....	.....
27	60-4-220	60.0	.....	.....	.....	.....	26.92	43.24	614.2	.....	.....	.....	.....
28	60-6-220	60.0	.....	.....	.....	.....	34.52	55.70	791.4	.....	.....	.....	.....
29	20-2-200	19.9	45.5	.....	5.89	10.07	13.35	47.25	223.5	28.32	3.47	3,571	189.6
30	20-4-200	19.9	59.4	682	7.20	9.43	19.76	61.05	287.6	26.24	3.51	4,943	262.2
31	20-6-200	20.0	.....	685	8.92	.....	26.95	79.31	375.8	26.01	.....	6,309	337.1
32	20-8-200	19.9	97.8	780	11.27	8.96	35.95	100.10	472.9	26.31	3.52	8,375	455.5
33	30-2-200	30.0	55.0	673	6.96	9.82	14.19	37.88	268.9	27.01	3.48	2,965	237.4
34	30-4-200	30.0	.....	682	8.56	.....	18.87	51.69	367.1	25.70	.....	3,847	307.4
35	30-6-200	30.0	98.0	788	11.12	8.83	26.75	68.90	489.2	24.91	3.40	5,380	430.1
36	30-8-200	30.6	.....	.....	.....	.....	34.75	87.83	635.7	.....	.....	.....	.....
37	40-2-200	40.0	60.6	676	7.59	9.75	13.28	32.42	306.6	26.88	3.35	2,257	240.5
38	40-4-200	39.9	86.7	.....	10.10	9.06	19.72	47.42	448.8	24.66	3.28	3,622	386.1
39	40-6-200	40.0	123.6	833	13.38	8.41	27.89	62.47	605.3	24.43	3.47	.....	.....
40	40-8-200	40.2	.....	.....	.....	.....	34.82	76.35	728.9	.....	.....	.....	.....
41	50-2-200	49.9	62.5	687	7.75	9.64	13.39	27.82	329.1	25.74	3.23	1,799	239.5
42	50-4-200	50.1	92.7	768	11.13	9.34	20.75	39.18	464.2	25.78	3.27	3,434	458.0
43	50-6-200	50.0	.....	.....	.....	.....	33.45	57.05	675.4	.....	.....	.....	.....
44	60-4-200	60.0	.....	.....	.....	.....	27.45	36.68	521.1	.....	.....	.....	.....
45	60-6-200	60.0	.....	.....	.....	.....	30.50	46.52	660.9	.....	.....	.....	.....
46	20-2-180	20.1	.....	595	5.07	.....	11.91	40.42	192.0	28.78	.....	2,814	150.5
47	20-4-180	20.1	.....	628	6.47	.....	18.97	55.48	263.6	26.76	.....	4,195	224.5
48	20-6-180	20.1	.....	673	7.75	.....	26.94	70.65	334.1	25.44	.....	5,377	287.3
49	20-8-180	20.0	.....	718	9.74	.....	34.17	86.77	411.7	25.91	.....	6,900	268.6
50	20-10-180	20.1	.....	.....	.....	.....	41.60	103.81	494.4	.....	.....	.....	.....
51	30-2-180	30.1	.....	654	5.76	.....	13.87	33.01	235.2	26.54	.....	2,179	174.9
52	30-4-180	29.8	.....	639	7.35	.....	19.23	44.97	317.2	25.36	.....	3,283	261.1
53	30-6-180	30.0	.....	688	8.81	.....	26.42	55.44	393.3	24.62	.....	4,188	334.5
54	30-8-180	30.1	.....	762	12.42	.....	34.20	77.29	546.3	24.61	.....	5,856	470.2
55	30-10-180	30.6	.....	.....	.....	.....	41.87	91.72	663.8	.....	.....	.....	.....
56	40-2-180	40.0	.....	636	6.13	.....	14.84	27.39	259.1	25.89	.....	1,726	181.6
57	40-4-180	40.6	.....	687	8.53	.....	20.82	40.71	386.2	24.08	.....	2,890	308.5
58	40-6-180	39.8	.....	750	11.47	.....	26.14	56.14	524.1	23.68	.....	4,039	427.9
59	40-8-180	40.4	.....	831	14.34	.....	34.80	64.16	609.9	25.85	.....	5,142	553.3
60	40-10-180	40.2	.....	.....	.....	.....	42.60	80.04	761.96	.....	.....	.....	.....
61	50-2-180	50.0	.....	639	6.53	.....	15.17	22.65	268.0	26.61	.....	1,305	173.8
62	50-4-180	49.9	.....	707	9.22	.....	21.13	34.85	410.62	24.43	.....	2,249	298.9
63	50-6-180	50.7	.....	778	12.55	.....	29.12	46.11	553.3	24.87	.....	3,355	453.4
64	50-8-180	50.0	.....	.....	.....	.....	35.20	58.46	692.0	.....	.....	.....	.....
65	60-4-180	60.0	.....	.....	.....	.....	28.20	30.98	440.1	.....	.....	.....	.....
66	60-6-180	60.0	.....	.....	.....	.....	34.35	42.24	600.2	.....	.....	.....	.....
67	20-4-160	20.0	42.5	631	5.55	10.16	18.89	46.43	219.5	28.03	3.29	3,281	174.7
68	20-6-160	20.0	56.3	667	7.04	9.72	25.65	62.95	298.4	26.14	3.20	4,731	252.2
69	20-8-160	20.0	.....	678	8.61	.....	33.50	72.92	345.1	27.52	.....	5,939	316.4
70	20-10-160	20.1	.....	.....	.....	.....	39.92	94.43	449.5	.....	.....	.....	.....
71	30-4-160	29.9	51.9	662	6.60	9.89	17.84	38.39	272.1	26.86	3.24	2,655	211.9
72	30-6-160	30.0	68.9	707	8.75	9.87	25.67	54.08	383.9	25.28	3.05	3,786	302.5
73	30-8-160	30.0	.....	763	10.91	.....	33.06	65.58	465.1	25.69	.....	5,130	410.86
74	30-10-160	30.0	.....	.....	.....	.....	43.30	79.47	564.3	.....	.....	.....	.....
75	30-12-160	30.8	.....	.....	.....	.....	46.80	90.38	658.6	.....	.....	.....	.....
76	40-4-160	40.1	63.4	690	7.94	9.73	19.62	33.49	317.5	26.48	3.39	.....	.....
77	40-6-160	39.9	87.6	761	10.32	9.16	26.11	45.65	431.7	25.82	3.45	.....	.....
78	40-8-160	40.2	.....	790	13.06	.....	34.80	57.02	543.9	26.44	.....	4,466	478.4
79	40-10-160	39.4	.....	.....	.....	.....	39.72	71.68	668.5	.....	.....	.....	.....
80	50-4-160	50.0	65.5	691	8.23	9.76	19.40	28.58	338.3	27.01	3.39	1,918	255.6
81	50-6-160	50.1	101.3	786	11.57	8.88	28.06	40.19	475.9	26.12	3.61	.....	.....
82	50-8-160	50.0	.....	.....	.....	.....	35.25	51.91	614.4	.....	.....	.....	.....
83	60-4-160	60.0	.....	.....	.....	.....	26.20	25.46	361.7	.....	.....	.....	.....
84	60-6-160	60.0	.....	.....	.....	.....	30.50	36.51	518.7	.....	.....	.....	.....
85	20-4-120	20.0	31.4	581	3.91	9.67	17.95	28.36	134.0	32.47	3.99	1,960	104.5
86	20-8-120	19.9	52.4	630	6.45	9.56	33.37	53.59	252.8	28.40	3.52	2,700	143.4
87	20-12-120	19.9	76.4	718	9.25	9.41	48.69	75.69	356.9	28.88	3.64	6,157	326.7
88	30-4-120	30.0	35.4	608	4.70	10.32	17.62	24.09	171.0	30.63	3.52	1,277	102.1
89	30-8-120	30.1	63.6	676	7.99	9.77	32.79	45.82	325.5	27.46	3.32	3,369	269.5
90	30-14-120	29.9	130.7	835	13.99	8.38	56.25	72.56	514.0	30.31	4.28	6,258	500.6
91	40-4-120	40.0	38.2	606	4.98	10.15	17.74	19.42	184.0	30.18	3.52	1,190	126.9
92	40-8-120	40.0	77.8	727	9.60	9.59	34.25	40.94	389.1	27.51	3.41	2,697	278.7
93	40-12-120	40.1	134.2	842	14.20	8.27	49.97	58.41	554.8	28.52	4.11	5,060	540.8
94	50-4-120	50.0	40.5	630	5.34	10.34	19.10	15.29	176.0	33.84	3.91	866	115.4
95	50-8-120	49.9	92.3	765	10.76	9.07	35.60	36.13	427.6	28.12	3.67	2,804	373.5
96	50-11-120	50.5	133.4	838	14.45	8.41	46.68	46.26	553.5	29.17	4.08	3,513	472.9
97	60-8-120	60.0	.....	.....	.....	.....	30.45	31.29	444.6	.....	.....	.....	.....

under different pressures fall in order, inversely with the pressure.

The results clearly define three general facts, which may be stated as follows:

1. The evaporative efficiency of a locomotive boiler is but slightly affected by changes in pressure.

2. Changes in steam pressure between the limits of 120 pounds and 240 pounds will produce an effect upon the efficiency of the boiler which will be less than 0.5 pound of water per pound of coal.

3. The equation $E = 11.305 - 0.221\ H$ represents the evaporative efficiency of the boiler of locomotive Schenectady No. 2 when fired with Youghiogheny coal for all pressures between the limits of 120 pounds and 240 pounds with an average error for any pressure which does not exceed 2.1 per cent.

Smoke-box Temperatures (Col. 5, Table IV).—The results show that in all cases the temperature of the smoke-box gases increases as the rate of evaporation increases and that it is very little affected by changes in pressure. Plotted diagrams showing the exact relationship indicate a marked similarity for all pressures; all have the same slope and if superimposed, they would fall very closely together. The equations of the mean line of such diagrams are given in the following table:

Boiler Pressure.	Equations.
220 pounds	$T = 496.3 + 25.66\ H$
200 pounds	$T = 491.0 + 25.66\ H$
160 pounds	$T = 487.7 + 25.66\ H$
120 pounds	$T = 478.9 + 25.66\ H$
Average	$T = 488.5 + 25.66\ H$

The data sustain the following conclusions:

1. The smoke-box temperature falls between the limits of 500° F. and 850° F., the lower limit agreeing with a rate of evaporation of four pounds per foot of heating surface per hour and the latter with a rate of evaporation of fourteen pounds per foot of heating surface per hour.

2. The smoke-box temperature is so slightly affected by changes in steam pressure as to make negligible the influence of such changes in pressure for all ordinary ranges.

3. The equation $T = 488.5 + 25.66\ H$ where T is the temperature of the smoke box expressed in degrees F., and H is pounds of water evaporated from and at 212° F. per foot of heating surface per hour, possesses a high degree of accuracy.

The Steam per Indicated Horse-power Hour (Col. 11, Table IV).—The steam consumption per indicated horse-power shown by the results of the tests implies a remarkably high efficiency. The narrow range which they represent, taken in connection with the comprehensive character of the running conditions involved, are matters of more than ordinary importance. For example, at a pressure of 240 pounds, the engine, when working under a fully open throttle, gave a horse-power hour in return for the consumption of less than 24 pounds of saturated steam, and under any condition of speed or cut-off for which it was found possible to operate the engine under a wide-open throttle, the consumption never exceeded 26.3 pounds. At lower pressures, involving the possibility of a wider choice in the condition of operating, the range is somewhat

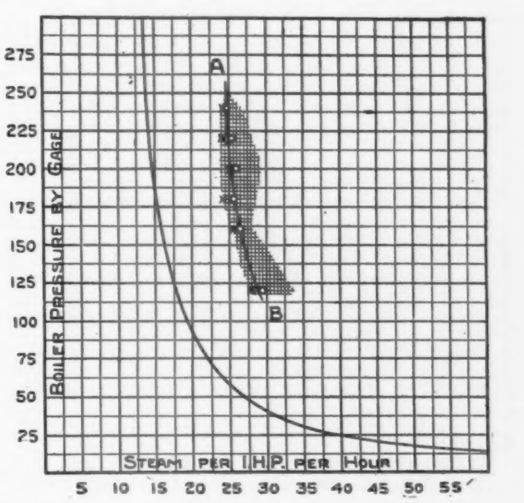


FIG. I.

increased. Thus, at 120 pounds pressure the minimum value is 27.5 and the maximum 33.8, ranges which, while greater than those just referred to, are nevertheless extremely narrow as compared with those which are incident to the operation of other classes of engines.

It appears from the data that the steam consumed by the cylinders varies for each different pressure with changes in speed and cut-off, and it has been sought to summarize the facts derived from the experiments into a single expression. This appears in the form of the curve AB, Fig I, which is to be accepted as representing the performance of the cylinders under different pressures without reference to speed or cut-off. Combining this general statement expressing cylinder performance with that obtained covering boiler performance, it should be possible to secure an accurate measure of the coal consumption per indicated horse-power hour, which will represent the results of all tests. The steps in this process are set forth by the several columns of Table III, in which the final results appear as Column 7. These representative values show a consumption of 3.3 pounds of fuel per indicated horse-power hour under a boiler pressure of 240 pounds, the consumption gradually increasing as the pressure is reduced until, under a boiler pressure of 120 pounds, it reaches its maximum value of four pounds per indicated horse-power hour.

TABLE III.

COMBINED ENGINE AND BOILER PERFORMANCE UNDER DIFFERENT PRESSURES, AS DERIVED FROM SUMMARIZED STATEMENTS COVERING THE PERFORMANCE OF ENGINE AND BOILER.

Boiler Pressure.	Steam per Indicated Horse-power per Hour. Values from Curve.	B. T. U. given to each Pound of Steam. Feed-water Temperature, 60 Degrees F.	Equivalent Pounds of Water per Indicated Horse-power Hour.	B. T. U. per Indicated Horse-power per Minute.	Equivalent Pounds of Water per Pound of Dry Coal.	Pounds of Coal per Indicated Horse-power Hour.
1	2	3	4	5	6	7
240	24.7	1,176.6	30.09	483	9.10	3.31
220	25.1	1,174.4	30 52	491	9.06	3.37
200	25.5	1,172.0	30.94	498	9.03	3.43
180	26.0	1,169.5	31.48	507	8.99	3.50
160	26.6	1,166.8	32.14	517	8.94	3.59
140	27.7	1,163.8	33.38	537	8 85	3.77
120	29.1	1,160.5	34.97	563	8.73	4.00

Results Corrected for the Several Tests.—The preceding paragraph constitutes a general statement setting forth the performance of the locomotive as affected by changes in pressure under conditions of speed and cut-off which are assumed to be typical of average running conditions. Corrected results applicable to the conditions of the several tests are presented by Table V (not reproduced). That is, the results of this table represent the performance on the assumption that the evaporation of the boiler is always represented by the equation,

$$E = 11.305 - 0.221 H.$$

TESTS WITH SUPERHEATED STEAM.

The Tests With Superheated Steam, the data for which are summarized in Table X, were run at four different pressures, namely, 240, 200, 160 and 120 pounds respectively, a range sufficient to afford an excellent comparison with results obtained by the use of saturated steam. The tests at 160 pounds pressure are sufficiently numerous to define the performance of the locomotive when operating under all conditions of speed and cut-off which can be maintained with a wide-open throttle. Tests at the other pressures involve the more usual positions of reverse lever and three different speeds.

The Evaporative Efficiency of the Combined Boiler and Superheater.—The standard fuel for these tests was Youghiogheny lump, an average analysis of which is as follows:

Moisture	1.89
Volatile matter	31.94
Fixed carbon	57.71
Ash	8.46
Heating value per pound of dry coal (B. T. U.)	14,047
Heating value per pound of combustible (B. T. U.)	15,372

The pounds of water evaporated from and at 212° F. per pound of dry coal, in terms of the rate of evaporation, are given by the following equations:

Boiler Pressure.	Equation.
240 pounds	$E = 11.532 - .214\ H$
200 pounds	$E = 11.612 - .214\ H$
160 pounds	$E = 11.568 - .214\ H$
120 pounds	$E = 11.928 - .214\ H$

where E is the number of pounds of water evaporated from and at 212° F. per pound of dry coal, and H is the number of pounds of water evaporated per square foot of water and superheating surface per hour. The area of the heating surface employed is based upon the interior surface of the fire box and the exterior surface of the boiler and superheater tubes.

It will be seen that the highest efficiency is obtained in connection with the lowest boiler pressure, and conversely that the lowest efficiency is obtained in connection with the highest boiler pressure. These results are in agreement with those obtained from locomotive Schenectady No. 2, using saturated steam. The explanation is not entirely apparent, though for some reason it appears easier to maintain a satisfactory condition of fire when the operation is under low pressure. In general, longer cut-offs were employed in connection with the lower pressures and the resulting difference in draft action may constitute the chief cause.

As noted in connection with the tests under saturated steam, differences due to changes in pressure are not great and for the purpose of defining the performance of the boiler in simple terms, they may be neglected. The equation of an average line is,

$$E = 11.706 - .214\ H,$$

where E is the equivalent evaporation from and at 212° F. per pound of dry coal for boiler and superheater and H is the equivalent evaporation per square foot of water and superheating surface. It is proposed to accept this equation as representing the performance of the combined boiler and superheater.

Evaporative Efficiency of the Boiler, Exclusive of the Superheater.—The pounds of water evaporated in the boiler from and at 212° F., exclusive of the superheater, per pound of coal, in terms of equivalent pounds of water evaporated per square foot of water heating surface in the boiler, is given by the equation,

$$E = 11.105 - .2087\ H.$$

This equation takes into account only that work done by the boiler.

The Degrees of Superheating.—The temperature of the superheated steam was measured by high-grade mercurial thermometers placed in the branch pipes at a point directly adjoining the connection to the superheater headers. The degree of superheat thus determined increases as the rate of evaporation increases and diminishes as the boiler pressure is increased. Equations derived from diagrams showing this relationship, which represent the experimental results with a high degree of accuracy, are as follows:

Boiler Pressure.	Equation.
240 pounds	$T = 54.4 + 7.28\ H$
200 pounds	$T = 74.2 + 7.28\ H$
160 pounds	$T = 85.0 + 7.28\ H$
120 pounds	$T = 87.1 + 7.28\ H$

where T equals the degrees superheat and H equals the equivalent pounds of water from and at 212° F. per square foot of water heating surface per hour. Assuming a constant rate of evaporation for the several boiler pressures, as, for example, 11 pounds, it appears that the amount of superheating increases when the boiler pressure is reduced, as follows:

When the pressure is 240 pounds, the degree of superheat is 135.
When the pressure is 200 pounds, the degree of superheat is 154.
When the pressure is 160 pounds, the degree of superheat is 165.
When the pressure is 120 pounds, the degree of superheat is 170.

The equation of an average straight line through these points is

$$T = 123 - .265\ P + 7.28\ H,$$

where T equals the degrees superheat, P the boiler pressure by gage, and H the equivalent evaporation per square foot of water-heating surface in the boiler.

The Ratio of the Heat Absorbed per Square Foot of Superheating Surface to that Absorbed per Square Foot of Water-Heating Surface expresses the relative efficiency of the water and of the superheater surface. This ratio increases in value as the rate of evaporation increases. Thus, when the boiler pressure is 160 pounds, it has a value of 34 per cent. when the rate of evaporation is 6, and 53 per cent. when the rate of evaporation is 14. The data show that at all other boiler pressures employed, the value of the ratio varies in exactly the same way, which is equivalent to the statement that the ratio is independent of boiler pressure.

Smoke-box Temperatures.—The temperature of the smokebox gases was read by a mercurial thermometer placed midway between the diaphragm and the front tube sheet. The results show, as would be expected, that the temperature increases with the rate of evaporation as in the case of those obtained in connection with saturated steam. Equations representing the exact relationship and which were obtained by drawing an average line through the actual points plotted against rate of evaporation are given in the following table:

Boiler Pressure.	Equation.
240 pounds	$T = 468.1 + 26\ H$
200 pounds	$T = 482.6 + 26\ H$
160 pounds	$T = 464.6 + 26\ H$
120 pounds	$T = 446.1 + 26\ H$
Average	$T = 465.35 + 26\ H$

The values indicated by these equations are somewhat less than those established by the tests with saturated steam.

Steam per Indicated Horse-power Hour.—Since tests representing the entire range of performance of the locomotive were run for only one pressure, 160 pounds, the variation of steam consumption from its maximum to its minimum value will be found only in the results of this series. (Table X.) Thus, at this pressure for a speed of fifty miles per hour and the reverse lever in the second notch from center forward, the actual steam consumption is 26.06 pounds per indicated horse-power per hour, which is the maximum value recorded. A minimum value of 20.29 is to be found when the speed is 40 miles per hour and the position of the reverse lever is eight notches from the center forward. If, however, these extreme values are omitted, the steam consumption for the remaining conditions of running varies but slightly.

TABLE X.
A SUMMARY OF OBSERVED AND CALCULATED DATA.
LOCOMOTIVE SCHENECTADY NO. 3. (SUPERHEATED STEAM.)

Designation of Tests. Number.	Designation of Tests. Laboratory Symbol.	Speed, Miles per Hour.	Dry Coal per Square Foot of Grate Surface per Hour, Pounds.	Smoke-box Temperature, Degrees F.	Superheating—Degrees F.	Equivalent Evaporation per Sq. Ft. of Heating Surface per Hour, Pounds.	Equivalent Evaporation per Pound of Dry Coal, in Boiler and Superheater.	Cut-off, Per Cent of Stroke.	Mean Effective Pressure, Pounds per Square Inch.	Indicated Horse-power.	Pounds of Steam per Indicated Horse-power Hour.	Pounds of Coal per Indicated Horse-power Hour.	Draw-bar Pull, Pounds.	Draw-bar Horse-power.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
101	30-2-240	30.2	69.2	726	138	9.43	9.75	15.52	51.80	369.8	23.43	3.20	3,905	314.2
102	30-4-240	29.1	93.8	775	153	11.52	8.79	21.40	69.30	476.7	22.11	3.35	5,258	407.3
103	30-5-240	29.4	......	...	149	......	......	25.41	76.75	534.1	21.68	....	5,910	463.2
103a	30-5-240	....	114.4	815	151	13.69	8.56	......	......	546.6	......	3.13	......	......
104	40-2-240	39.7	76.1	714	127	9.83	9.24	16.34	44.17	415.1	21.89	3.56	3,295	348.8
105	40-4-240	39.9	107.9	798	154	13.08	8.67	23.40	58.81	551.4	21.32	3.33	4,596	485.3
106	50-2-240	50.6	82.2	761	143	10.96	9.52	17.32	38.78	463.9	21.64	3.02	2,723	367.0
107	30-2-200	30.2	52.7	662	132	7.16	9.72	14.68	39.29	280.4	22.93	3.20	2,816	226.3
108	30-4-200	30.0	73.9	724	152	9.17	8.88	20.86	53.99	383.4	21.59	3.28	4,154	332.2
109	30-6-200	30.4	90.8	787	169	11.47	9.04	27.13	71.94	517.0	19.93	2.99	5,471	442.9
110	40-2-200	39.9	55.5	687	138	7.71	9.94	16.33	32.76	309.6	22.41	3.05	2,396	255.4
111	40-4-200	40.4	......	...	153	......	......	22.41	48.83	466.5	21.09	....	3,549	382.2
111a	40-4-200	40.3	91.1	747	153	10.89	8.55	......	......	445.2	......	3.48	......	......
112	40-6-200	40.8	101.1	824	178	13.18	9.34	29.51	60.95	588.6	20.07	2.92	4,714	512.6
113	50-4-200	48.2	99.2	778	159	10.82	7.82	22.75	42.74	487.5	20.03	3.46	3,219	413.7
114	20-2-160	19.9	38.7	633	180	4.88	9.10	14.48	35.35	166.8	27.11	3.95	2,367	125.8
115	20-4-160	19.9	44.2	627	133	5.91	9.56	21.46	49.19	232.2	23.71	3.24	3,457	183.5
116	20-6-160	20.0	58.6	691	154	7.58	9.26	27.09	63.41	300.2	23.03	3.32	4,466	238.0
117	20-8-160	20.0	76.0	690	145	9.09	8.56	35.56	77.30	366.7	22.82	3.52	5,836	311.6
118	30-2-160	30.1	38.1	601	125	5.56	10.46	14.29	26.91	191.5	26.18	3.38	2,028	162.5
119	30-4-160	29.9	49.9	669	142	7.02	10.06	20.47	40.39	285.4	22.93	2.98	3,043	242.1
120	30-6-160	30.0	74.8	695	163	9.40	8.99	27.12	54.59	387.4	22.11	3.28	4,065	324.9
121	30-8-160	30.0	82.7	764	173	11.27	9.74	34.22	67.80	481.8	21.20	2.92	5,342	427.5
122	40-2-160	40.9	39.6	613	123	5.89	10.65	14.94	21.85	211.5	25.46	3.18	1,291	140.7
123	40-4-160	40.2	63.6	682	154	7.86	8.85	21.29	36.07	343.3	21.52	3.15	2,279	244.2
124	40-6-160	40.1	75.4	722	165	10.07	9.55	27.83	45.35	429.8	21.44	2.98	3,688	393.8
125	40-8-160	40.1	97.9	775	180	13.29	9.72	36.90	63.13	598.7	20.29	2.78	4,577	488.9
126	50-2-160	49.9	40.8	600	118	5.80	10.19	15.66	15.27	180.2	29.06	3.85	1,115	148.3
127	50-4-160	49.9	67.0	676	152	8.41	8.98	22.33	29.09	343.1	22.21	3.32	2,107	279.9
128	50-6-160	50.0	107.7	797	214	13.71	9.12	28.00	43.96	520.0	23.59	3.52	3,140	418.3
129	30-4-120	30.1	31.7	568	117	4.86	10.98	19.38	23.00	163.3	27.27	3.30	1,715	137.2
130	30-8-120	30.3	58.1	676	156	8.25	10.16	35.31	46.84	335.3	23.05	2.95	3,654	294.6
131	30-10-120	29.8	89.1	702	175	9.90	7.95	42.73	58.12	409.7	22.07	3.70	4,638	368.2
132	30-14-120	30.0	130.9	772	191	12.77	6.98	57.04	72.95	517.5	22.56	4.30	5,758	459.9
133	40-4-120	39.9	35.8	579	121	5.12	10.24	20.47	18.89	178.6	26.39	3.41	1,325	141.0
134	40-8-120	39.9	74.3	692	171	9.30	8.95	35.60	40.52	382.9	22.27	3.30	3,195	340.0
135	40-12-120	39.9	133.9	782	190	13.30	7.10	51.19	57.93	547.6	22.20	4.16	4,697	500.0
136	50-8-120	50.1	80.2	715	169	10.20	9.10	35.54	34.76	411.8	22.74	3.32	2,731	364.3

Steam Consumption Under Different Pressures.—The steam consumption in pounds per indicated horse-power per hour plotted with boiler pressure is presented graphically by Fig. 2. The shaded zone encloses an area within which the results of all tests fall. For purposes of comparison, however, it is desirable to define this performance by a single line. In reducing this zone to a representative line, the results of all second-notch tests at 160 pounds pressure, which represent very low power and which are, therefore, abnormal, have been omitted, and in a few cases extrapolated values for other pressures have been inserted. The average of results thus set apart for the purpose is shown by the circles, Fig. 2. The line AB drawn through these circles is assumed as the representative line sought. The points indicated by crosses near the left-hand margin of the shaded zone represent the average of the minimum steam consumption for the several speeds under each different pressure.

Coal Consumption Based on the Derived Performance of the Locomotive.—The coal consumption as set forth in the numerical data represents values actually obtained. Values forming a more logical basis for comparison may be derived from equations expressing the performance of the boiler and superheater and the engine as already developed. Thus, the equation defining the performance of the boiler and superheater combined is,

$$E = 11.706 - .214\ H,$$

and that defining the performance of the superheater is,

$$T = 123 - .264\ P + 7.28\ H,$$

and that of the engine is defined by the curve AB shown in Fig. 2.

It is now proposed to determine the coal consumption per indicated horse-power, per hour, assuming the efficiency of the locomotive to be that defined in the above relationship. Several steps in the process appear in order in the several columns of Table IX, the results sought being those of Column 7.

From the values given in the table, it will be seen that the coal consumption per indicated horse-power hour varies from 2.97 to 3.31. The minimum value, 2.97, is found at 200 pounds boiler pressure.

Corrected Results.—Following the method already described for correcting the results of tests with saturated steam to eliminate incidental discrepancies, the values of Table X representing steam and coal consumption have been recalculated and are presented as Table XI (not reproduced). They are those which would have been obtained if the evaporative efficiency for all tests had been that expressed by the equation,

$$E = 11.706 - 0.206\ H.$$

A DISCUSSION OF RESULTS OBTAINED WITH SATURATED AND WITH SUPERHEATED STEAM.

The two locomotives tested were identical except with reference to those details of construction involved by the presence of the superheater. The machinery of

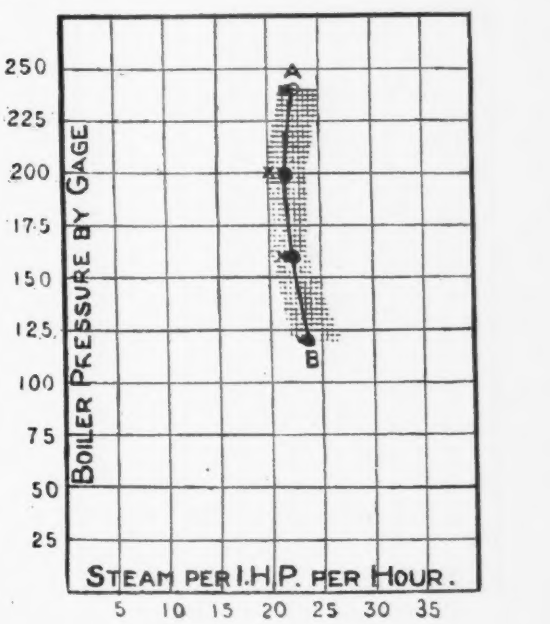


FIG. 2.

the engine, including cylinders and valves, was the same, as was also the shell of the boiler, the fire box and the grate. The weight of the locomotive on its truck was probably greater in the case of the superheating locomotive, but the increase was very slight. Differences appear, however, in the number, size and arrangement of the flues and steam piping and, as a consequence, in the extent of heating surface. Youghiogheny coal was the standard fuel. In the record of tests under saturated steam, results dependent on the fuel record are omitted when other coal was employed,

TABLE IX. LOCOMOTIVE PERFORMANCE UNDER DIFFERENT PRESSURES.

Boiler Pressure.	Pounds of Steam per Indicated Horse-power Hour. Values from Curve.	B. T. U. per Pound of Steam. Feed 60 Degrees F. and Superheat from Equation.	Equivalent Pounds of Steam per Indicated Horse-power Hour.	B. T. U. per Indicated Horse-power per Minute.	Equivalent Pounds of Steam per Pound of Dry Coal.	Pounds of Coal per Indicated Horse-power Hour.
1	2	3	4	5	6	7
240	22.6	1,258.7	29.45	474	9.426	3.12
220	21.8	1,261.8	28.48	459	9.501	3.00
200	21.6	1,263.1	28.25	455	9.518	2.97
180	21.9	1,261.7	28.61	461	9.491	3.01
160	22.3	1,259.3	29.07	468	9.455	3.08
140	22.9	1,256.4	29.79	481	9.399	3.17
120	23.8	1,252.7	30.87	497	9.316	3.31

and in the record of tests under superheated steam it has been possible to reduce results obtained with other coal to equivalent results which would have been obtained had the standard fuel been used.

A Comparison of Boiler Performance.—The boiler of Schenectady No. 2 as designed to deliver saturated steam gave an efficiency which is expressed by the equation,

$$E = 11.305 - .221\ H,$$

while the boiler of Schenectady No. 3 as equipped with a Cole superheater gave an efficiency expressed by the equation,

$$E = 11.706 - .214\ H.$$

Obviously, on the basis of these equations, the superheating boiler has the advantage. The comparison is, however, not a fair one, since in both cases the equations are based on the extent of heat-transmitting surface, and this, in Schenectady No. 2, was greater than the combined water-heating and superheating surface of No. 3. To make the equation fair, the term in the equation representing equivalent pounds of water per square foot of heating surface (H) must be expressed in terms of the total power delivered by the boiler. Comparisons on this

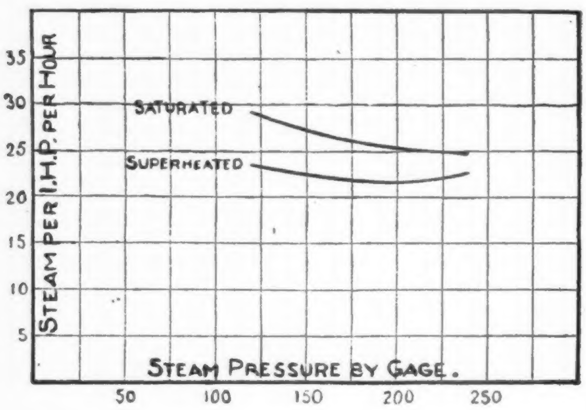


FIG. 3.

basis, showing the performance of the boiler in one case and of the boiler and superheater in the other case, expressed in terms of equivalent evaporation, show that even upon this basis the efficiency of the combined boiler and superheater is superior to that of the boiler alone, the increase averaging between three and four per cent.

Comparisons Involving Engine Performance.—The steam consumption per indicated horse-power hour for the saturated steam locomotive, as determined by the results of eighty-seven tests, has been defined by the line AB, Fig. 1, while that of the superheating locomotive, as determined by the results of thirty-eight tests, has been defined as the line AB, Fig. 2. Replotting the results presented by these figures upon a single sheet gives the diagram shown by Fig. 3. This exhibit, or perhaps better, the numerical value given in Columns 2 and 4 of Table XII, shows well the saving of water which is realized by the substitution of steam superheated approximately 150° F., for steam which is saturated. The saving ranges from 18 per cent. when the boiler pressure is 120 pounds to 9 per cent. when the boiler pressure is 240 pounds. It appears, also, that with superheated steam, the least consumption, 21.6, is secured when the boiler pressure is approximately 200 pounds and that variations in the consumption resulting from changes in pressure are slight. For example, the water consumption for all pressures between 160 pounds and 220 pounds falls between the limits of 21.6 pounds, the minimum value obtained, and 23.2 pounds, a range of approximately four per cent.

The saving of water in locomotive service is always a matter of moment. By reducing the time required to take water, the exactions of certain conditions in operation are diminished, and in some districts where water is bad or hard to obtain, difficult problems either in locomotive maintenance or in the maintenance of the water supply are simplified. The fact, therefore, that superheating affords a material saving in the amount of water required is not to be overlooked in estimating the value of superheating as a practice. But the saving in heat is not proportional to the saving in water, for each pound of superheated steam represents a larger amount of heat than a pound of saturated steam at the same pressure. As an indication of the thermal advantage to be derived from the use of superheated steam in comparison with that of saturated steam, it is desirable to reduce the consumption in each case to the same thermal basis. This has been done with results which are shown numerically by Table XII. From these exhibits it is evident that the saving effected by the use of superheated steam when the pressure is 120 pounds is not less than twelve per cent., and when the pressure is 240 pounds approximately two per cent. Under a boiler pressure of 180 pounds, the substitution of superheated steam for saturated steam improves the efficiency of the engine 9.1 per cent. The results show, also, that the performance of the

TABLE XII.

STEAM PER INDICATED HORSE-POWER HOUR.

Boiler Pressure, Pounds.	Saturated Steam.		Superheated Steam.	
	Pounds of Steam per Indicated Horse-power per Hour.	B. T. U. per Indicated Horse-power per Minute.	Pounds of Steam per Indicated Horse-power per Hour.	B. T. U. per Indicated Horse-power per Minute.
1	2	3	4	5
240	24.7	483	22.6	474
220	25.1	491	21.8	459
200	25.5	498	21.6	455
180	26.0	507	21.9	461
160	26.6	517	22.3	468
140	27.7	537	22.9	481
120	29.1	563	23.8	497

superheating locomotive is affected by changes of pressure to a much smaller extent than that of the saturated steam locomotive.

Comparisons Involving the Performance of the Locomotive as a Whole.—The performance of the locomotive as a whole, in terms of coal consumed per indicated horse-power hour, both for saturated steam and superheated steam, is shown numerically by Table XIII. This shows that the gain resulting from the use of superheated steam is most pronounced at the lower pressures. Thus, at a pressure of 120 pounds it is seventeen per cent., while at a pressure of 240 pounds it is but six per cent. They show, also, that the performance of the locomotive using superheated steam is only slightly affected by changes of pressure for the entire range of pressure between 120 pounds and 240 pounds. With superheated steam the difference in coal consumption from minimum to maximum is but a third of one pound, while for pressures between 175 pounds and 225 pounds it is practically constant and always near the minimum. The least coal consumption per indicated horse-power hour as it appears in the summarized statement is 2.97. It was obtained under a steam pressure of 200 pounds. The results sustain a claim which has been put forward by advocates of the practice of superheating to the effect that the adoption of such practice permits a material reduction in steam pressure as compared with

TABLE XIII.

SAVING IN COAL EFFECTED BY THE USE OF SUPERHEATED STEAM.

Boiler Pressure Pounds.	Pounds of Coal per Indicated Horse-power per Hour.		Saving Effected by the Use of Superheated Steam.			
			Over Values Obtained with Saturated Steam at Same Pressure.		Over Values Obtained with Saturated Steam at 180 Pounds Pressure.	
	Saturated Steam.	Superheated Steam.	Pounds per Indicated Horse-power per Hour.	Per Cent.	Pounds per Indicated Horse-power per Hour.	Per Cent.
1	2	3	4	5	6	7
240	3.31	3.12	.19	5.72	.38	10.86
220	3.37	3.00	.37	10.98	.50	14.29
200	3.43	2.97	.46	13.31	.53	15.15
180	3.50	3.01	.49	14.00	.49	14.01
160	3.59	3.08	.51	14.21	.42	12.00
140	3.77	3.17	.60	15.98	.37	10.57
120	4.00	3.31	.69	17.25	.19	5.43

pressures now common in locomotive service without materially sacrificing efficiency. A detailed numerical statement showing the saving in coal resulting from a change from saturated to superheated steam is set forth in Columns 4 to 7, inclusive, of Table XIII.

Comparisons Involving Capacity.—The maximum power presented by the data derived from the locomotive using superheated steam is not to be accepted as a measure of its capacity. Except in the case of the series of tests run at 160 pounds pressure, the number of tests was insufficient to permit the estab-

lishment at each speed of a maximum cut-off for which the boiler could be made to supply steam. But while the direct evidence is lacking, the data contain much which goes to show that the superheating locomotive is a more powerful machine than the locomotive using saturated steam. For example, it has been shown that, for the development of equal amounts of power, the combined boiler and superheater of the superheating locomotive has an efficiency which, if it does not exceed, certainly equals that of the saturated steam locomotive. But each unit of power delivered from the boiler in the form of superheated steam is more effective in doing the work in the cylinder than a similar unit of power delivered in the form of saturated steam. Hence, at the limit, the superheating locomotive is the more powerful locomotive and the gain equals that which measures the difference in the economy with which the cylinders use steam.

The same question may be dealt with through another series of facts as follows: It can be shown that the power of any locomotive is limited by its capacity to burn coal, and coal-burning capacity is a function of the draft. The data show that for the development of a given cylinder power, the draft values of Schenectady No. 3 (superheating) were in all cases less than those of Schenectady No. 2 (saturated). These differences are of small value for tests under high pressure, but they increase as the pressure is reduced. For example, tests at 160 pounds pressure show that the power developed in return for a given draft is from ten to sixteen per cent. greater for the superheating locomotive than for the locomotive using saturated steam. Obviously, there is no reason why the draft for the former should not be increased to limits practicable for the latter and when this is done, the power developed by the superheating locomotive would exceed that which is possible with the saturated steam locomotive by from ten to sixteen per cent.

Concerning the Possible Degree of Economy Which May Result from the Use of Superheated Steam.—In the preceding paragraphs an attempt has been made to define with accuracy the increased efficiency resulting from the substitution in locomotive service of steam superheated to approximately 150° for steam which is saturated. The facts upon which comparisons have been based have been derived from carefully selected processes and the results can safely be accepted as the measure which has been sought. All discussion might well end with the presentation of these facts were it not that out of them arises a group of questions of great practical significance. To some of these attention may well be given.

As a general proposition, the gain which in any service will result from the introduction of a superheater is a function of the degree of superheat which is employed. The experience of the Prussian State Railway shows that superheaters may be designed and operated which deliver steam having a temperature of from 300° to 350° C. The latter value, however, is regarded as the maximum limit which must never be exceeded. Under normal conditions of running, however, the degree of superheat with a boiler pressure of 180 pounds considerably exceeds 200° F., which is not less than thirty-three per cent. in excess of the degree of superheat used in the experiments herein discussed. *It has been shown, also, that the production and use of steam at this temperature introduce no difficulties either in the maintenance of the superheater nor in the parts of the machine which come under its influence.* It is claimed that the advantage to be derived from the use of superheated steam *increases more rapidly than the degree of superheat. But assuming the gain to be no more than proportional to the degree of superheat employed,* it is evident that the curves showing performance under superheating would be lower by *thirty-three per cent.* of the saving shown, had the temperature of the delivered steam in the locomotive experimented upon equaled that prevalent in German practice.

Upon this basis it can be shown that, under a boiler pressure of 180 pounds, there would be a reduction of water consumption from 26 pounds to 20.5 pounds, *a saving of twenty-one per cent.*, and a reduction of coal consumption per drawbar horsepower of from 4 pounds to 3.25 pounds, a saving of *nineteen per cent.* These values may be accepted as not far from those which should be expected from the adoption of superheating in locomotive service.

It will be a mistake, however, for one to assume that a railway company's bills for locomotive fuel may be diminished by the percentages set forth in the preceding paragraph, merely through the introduction of the superheater. It should be clear, for example, that no part of the fuel used in firing-up a locomotive in the roundhouse, nor of that consumed in maintaining the temperature of a locomotive between the roundhouse and the time of its starting at the head of its train can be saved by the application of a superheater. Again, fuel which is used in maintaining the normal temperature of all parts of the machine when the locomotive is at rest at stations and at passing points, in making good steam losses by safety valve and by leaky valves and pistons or which comes through glands and cylinder cocks must be regarded as fuel which cannot be saved through the presence of the superheater. Estimates based upon careful observations on several roads have shown that the fuel used in these ways amounts to about twenty per cent. of the total fuel delivered to the locomotive. It appears, therefore, that the saving which is to be brought about by the adoption of the superheater is applicable to approximately eighty per cent. of the fuel which, under service conditions, is delivered to the tenders of locomotives using saturated steam.

A Summary of Significant Conclusions.—The substitution of superheated for saturated steam under conditions where the power to be developed is fixed, will permit:

1. The use of comparatively low steam pressures, a generally accepted limit being 160 pounds.

2. A saving of from fifteen to twenty per cent. in the amount of water used.

3. A saving of from ten to fifteen per cent. in the amount of coal used while running, or of from eight to twelve per cent. in the total fuel supplied.

4. Assuming the power developed to equal the maximum capacity of the locomotive in each case, the substitution of superheated for saturated steam will permit an increase of from ten to fifteen per cent. in the amount of power developed, accompanied by a reduction in total water consumption of not less than five per cent. and by no increase in the amount of fuel consumed.

Discussion.—Robert Quayle related an experience with a fire tube superheater which had been in service on his road for seventeen months. This superheater has not had repairs of any kind, nor has it been changed in any way during that time. The engineer operating the locomotive, covering 276 miles per day, had stated that if he could not have the superheater on the engine otherwise he would like to buy one out of his own pocket. The locomotive was considered to be at least one sleeping car better than the same engine without it. Records did not show, however, that there was any noticeable saving in fuel, but the extra work which the locomotive did more than made up for this. This road is planning on making exhaustive tests on some superheating locomotives which are now under construction.

J. B. Elliott (C. P. R.) stated that the division superintendents on his road were very anxious to get superheating locomotives for their heavy passenger trains. It has been found that much better time could be made with them than with the other engines and that engine failures were much less frequent.

Mr. Fuller (U. P.) stated that on his road there had been trouble with the slide valves cutting when used with superheated steam. The difficulty had been overcome by using bronze false seats.

In speaking on this subject President Vaughan said:

"Apart from my own impression, I'll say that our talks with our various master mechanics, and the superintendent of motive power of our Western lines, which really constitute an independent organization to a great extent, are such that the question of applying superheaters with us never comes up. We look upon it just as much as an attachment to the locomotive to-day as we do the cylinders. We would not think of giving it up. The only question is as to what type of superheater we shall use, or what shall be done to take care of it and things of that sort. We have not for the past two or three years really seriously considered the question whether we should use the superheaters or not—they have been used as a matter of course. We have between 200 and 300 compound engines, and the other day a request came from the general manager of the western lines that he wanted some compounds, that were bought only four years ago, converted to superheaters for the sake of the economy in the maintenance. Superheater engines are so much cheaper to maintain that he wanted the change made for the sake of his accounts."

He also stated that the experience on his road with a large number of superheating locomotives had been a greater economy than that shown by Dr. Goss' paper, and explained this by the fact that inasmuch as his engines were larger, the boiler heating surface was not disturbed to so great an extent by the application of the superheater, and also that the fireman was not worked so hard on the superheating locomotives and were thus capable of doing better work than on the saturated steam engines with which they were being compared. On the testing plant equally good work was done by the fireman on both locomotives.

In speaking about trouble in the cylinders and valves with superheated steam, he stated:

"We have had a great deal of trouble in the past few years with piston rings, but very little trouble with valve rings; but we did have considerable valve trouble. Now, strangely enough, when we first went into superheating, we did not have much trouble in that respect, and I can only say that I am not at all satisfied yet whether our trouble is due to superheated steam or due to changes in our foundry practice. Roads using saturated steam have occasionally had serious packing troubles, the wear of piston rings, etc., depending on the metal being porous. We are going into the question of improving our packing, and think we are obtaining considerably better results. The trouble does not occur in all cases, but it is a serious question with us; that is to say, we have rings that have worn out as quickly as six weeks or two months, and others will last eight or nine months. We have experimented with the substitution of Dunbar for split-ring packing, and we have found that it has lasted some nine or ten months without renewal, and we believe, after we use the Dunbar packing generally, we will have no serious trouble with the cylinders. The bushings in both the cylinders and the valve chests are not hurt, the valve rings are not hurt, but we have a certain amount to learn about the proper material and proper style of packing ring to use. We do not consider the matter very serious and it does not show up on our repair bills."

In connection with engine failures on superheated steam locomotives he had recently had records compiled for eight months, during which time there were but five superheater failures giving 300,000 miles to a failure. Three of these failures were on the same engine on successive days.

F. F. Gaines (Cent. of Ga. Ry.) reported success with a locomotive fitted with a Baldwin superheater. The locomotive is a favorite with engineers and repairs have been very light, no trouble having been found with valves or pistons. He also stated that a feed water heater locomotive shows a much greater fuel economy than does the superheater engine. (See American Engineer, June, 1909, page 241.)

President Vaughan, in reply to a question by Mr. Wildin, stated that he would recommend the application of superheat to all passenger locomotives, irrespective of the price of coal in any district on account of the increased capacity which could be obtained. The application to freight locomotives would be determined largely by the price of coal.

Prof. Hibbard drew attention to the fact that the tests reported by Dr. Goss were at 150 degrees of superheat and gave the most efficient point at about 200 lbs. boiler pressure. He suggested that possibly with higher degrees of superheat the most efficient boiler pressure might be raised, and that this possibly might give a still greater degree of efficiency.

L. R. Pomeroy stated that since a locomotive with 180 lbs. of steam pressure with a superheater gave better results than one of 210 lbs. pressure without a superheater, the matter of first cost and repairs, which are somewhat proportional to the pressure, should be considered, and the added economy of this should be added to that obtained by the superheater directly.

H. W. Jacobs (Santa Fe) stated that the superheater locomotives on his road had required decidedly less repairs than the others of the same class without superheaters.

F. C. Cleaver (Rutland) reported success with superheaters on his road. The engines were decidedly quicker and more snappy than were either the compounds or saturated steam engines.

Several other gentlemen reported success with superheated steam, and there were no great difficulties mentioned or criticisms offered to its use.

FEDERAL BOILER INSPECTION BILL.

The report of the special committee on the bill for Federal Boiler inspection, which is now before the U. S. Senate, was as follows:

It is the opinion of the association that such a law is entirely unnecessary and will not promote any greater safety of operation, for the following reasons:

First—That the railways maintain efficient systems of inspection and tests of locomotive boilers and appurtenances under carefully prescribed rules, which are prepared to best meet general and local conditions, the railways having the greatest possible interest in the thoroughness of this protection.

Second—Experience covering a period of many years has shown conclusively that such failures of locomotive boilers as have occurred would not be eliminated by the proposed law, as investigation has shown that they were not due to defective design, construction, weakness or lack of proper appurtenances or periodical inspection.

We would, in addition to the above, recommend that the subject be given full consideration by the executive committee.

WIDENING GAGE OF TRACKS.

The committee on this subject was appointed to co-operate with a committee of the American Railway Engineering and Maintenance of Way Association, and also co-operate with the wheel committee of the M. C. B. Association. It reported that the former association at its last convention had adopted 1¾-in. width of flangeway as a standard, and it had also taken action to the effect that the gage of track should be corrected when, due to worn rail heads, it had increased ½ in. beyond the standard gage. The subject, however, of the widening of gage on curves, is not yet completed, and the committee asked to be continued.

Mr. Fowler recounted some very interesting tests which he has in progress on an electric railway in connection with this subject. The committee was continued.

[*Abstract of committee reports and outline of the discussion thereon will be continued in the August issue, the following subjects being given: Bank vs. Level Firing, Individual paper by E. D. Nelson; Castle Nuts; Lubricating Material Economies; Motor Cars; Fuel Economies; Tender Trucks, and Safety Valves. The topical discussions on the floor of the convention will be reviewed in the same issue.*]

Publicity of Railroad Accidents.—The policy of the Harriman Lines is to be frank with the public in company matters. When a serious accident occurs, an open board of inquiry is promptly convened by the division superintendent, consisting of himself, the master mechanic, the division engineer, and two or more prominent representative citizens. This board, a high class jury, hears evidence and publishes its findings in the local press. Not infrequently a newspaper man is a member of the board. If this board does not get to bottom facts, a second is convened, composed of general officials and of prominent citizens of the state; for example, an ex-governor, a well known banker, a leading editor, a retired general officer of the army, etc. This policy has greatly improved discipline and educated public sentiment. The men are eager to avoid the published censure of their fellow citizens. The public is pleased with the frankness of the companies and sympathizes with their difficulties. Personal injury settlements are no heavier—if anything, are lighter—under this policy. It is idle to argue that liability can be avoided by a suppression of information.—*J. Kruttschnitt before the New York Railroad Club.*

The Need of Better Educational Methods.—Not more than one out of 130 children go to colleges or universities; not more than one out of 30 go to the high schools, while less than 25 per cent. of all our children fail to pass through the primary grades. The result is an extraordinary amount of inefficiency for the work that these young people have to perform. The present system of education is one in which the schools are so correlated and co-ordinated as to take for granted that each boy and girl is to go through college. All this may be very perfect in form, but each fails absolutely in doing that which is demanded of a good school system, namely: to prepare students for their life work. It is time to take hold of this great big question of education and establish methods of making, not working men and working women, but men and women working. *—Prof. J. C. Monaghan, Secretary, Nat. Soc. for Promotion of Industrial Education.*

MASTER CAR BUILDERS' ASSOCIATION

FORTY-THIRD ANNUAL CONVENTION.

The meetings were held in the Greek Temple on Young's Million Dollar Pier at Atlantic City, June 21, 22 and 23.

PRESIDENT'S ADDRESS.

In his presidential address, R. F. McKenna, master car builder of the Delaware, Lackawanna & Western Railway, spoke in part as follows:

"Rigid economy by railway companies throughout the country has prevailed during the past year. It has been largely compelled by federal and state legislation that caused investors to hesitate in accepting securities offered, and mechanical departments of railways have suffered. This condition has been more acute during the period mentioned than at any time since 1894, and at no time in the history of railways has their ownership and management been subjected to so much adverse criticism from those who have no intimate knowledge of railway affairs.

"With an ill-advised desire to gain popularity, certain public men and some of the press have constituted themselves guardians of public welfare. To achieve their ends they have caused great injury to commercial life, and corresponding damage to railway companies. Until legislative bodies repeal the disastrous federal and state laws they have enacted, the public at large, which includes railway owners, managers, employees and patrons of the transportation companies, will continue to be more or less affected.

"Railway companies in their zeal to economize, to protect themselves, and to conserve the best interests of all concerned, are buying only such materials and employing no more labor than is absolutely essential to the daily conduct of affairs, husbanding their resources until conditions again become stable. Appearances suggest that there is to be a respite from unfair legislation, and incidentally unjust criticism.

"The arbitration committee has devoted studious care to the preparation of the rules of interchange, and the rules promulgated by them are eminently fair, both to car owners and to companies making repairs. Practices that should be frowned upon have become general on certain lines, resulting in great annoyance, and often in decided financial loss to car owners. Mechanical departmental and divisional heads should therefore instruct foremen, inspectors, repairmen, billing clerks and others that bills must of necessity be prepared in accordance with the prescribed rules of the association. The unfair practices that are being followed by certain car owners can be made a matter of history if mechanical department heads issue necessary instructions, and in fairness to all concerned this should be done.

"Care should be taken by the various committees of the association, and also by the association itself, in adopting new standards or advancing recommended practices to standards; but when, after due care and thought on the part of committees of the association, standards are adopted, they should be more generally followed by car owners.

"The question of an M. C. B. standard coupler deserves the most careful thought and research on the part of car owners and coupler manufacturers. Something should be done without any unnecessary delay to relieve the railway companies of the necessity of carrying vast quantities of repair parts for various makes of couplers. Interchangeability is possible and should be worked out to a satisfactory conclusion. It would perhaps be well if the association at this time recognized the side as well as the center unlocking arrangement for couplers.

"For years the question of consolidating the Master Car Builders' and the American Railway Master Mechanics' Associations has been the subject of discussion. Such action has heretofore not been deemed either necessary or desirable, and conditions at present do not indicate that it would now result in any benefit to railway companies. Unless improvement is possible, changes should not be favored. The two associations are separate and distinct so far as their line of action is concerned. The Master Mechanics' is of a technical character, having no legislative powers, and as the Master Car Builders find it impossible to devote sufficient time to the proper consideration of the various reports submitted to them, the proposed consolidation seems unwise, especially as new topics, new subjects and new discussions would be introduced into our deliberations. There is sufficient work for each association in its own particular field, and as the method of procedure in handling work incident to locomotive repairs and construction, car repairs, construction and interchange, differs so very materially, it would seem desirable to handle them as two separate and distinct branches, so that the questions incident to each will be considered by two separate and distinct associations."

Secretary's Report.—The membership is as follows: Active, 447; representative, 292; associate, 13; life, 17; total, 769. There are 2,403,961 cars represented in the association, a gain of 120,363 over last year. Twenty-three railways and private car lines have during the past year become subscribers to the rules governing the interchange of freight cars. Two railways have signified their acceptance of the rules governing the interchange of passenger cars.

Treasurer's Report.—There is a balance of $526.11 on hand.

Life Members.—E. W. Grieves, a past president, and W. C. Ennis were elected life members.

Height of Drawbars.—On motion of C. E. Fuller, S. M. P., Union Pacific, the following resolution was adopted:

"Resolved, That the maximum height of drawbars for freight cars measured perpendicular from the level of the tops of rails to the centers of drawbars for standard gage railways in the United States shall be 34½ inches, and the minimum height of drawbars for freight cars measured in the same manner shall be 31½ inches." This simply makes more clear the intent of the resolution presented to the Interstate Commerce Commission in 1893.

Tillotson Bequest.—Through the will of Mrs. Emma A. Tillotson, the association was bequeathed the sum of $5,000. It was decided that the bequest be received and invested, and the interest thereon applied to such investigations as the executive committee may recommend to the association, the form of investment to be left with the treasurer subject to the approval of the executive committee.

Specification for Lumber.—A resolution was adopted to the effect that the executive committee appoint a committee to cooperate with a committee from the Railway Storekeepers' Association in drawing up of uniform specifications for lumber to meet railway requirements.

Election of Officers.—The following officers were elected:

President—F. H. Clark (C., B. & Q.); first vice-president—T. H. Curtis (L. & N.); second vice-president—LeGrand Parish (L. S. & M. S.); third vice-president—A. Stewart (Southern); treasurer—John Kirby, Adrian, Mich.

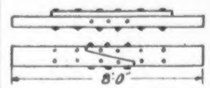
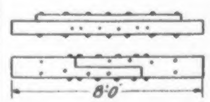
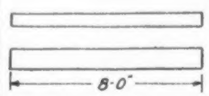
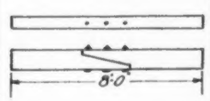
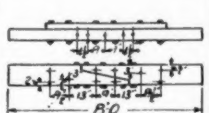
Executive Committee—D. F. Crawford (Pa. Lines); F. W. Brazier (N. Y. Cent.); C. A. Schroyer (C. & N. W.); J. D. Harris (B. & O.); C. E. Fuller (U. P.) (hold over); H. D. Taylor (P. & R.) (hold over).

REVISION OF THE CONSTITUTION.

A number of changes were made in the constitution and by-laws. The most important was that active members retiring from railway service are either dropped from membership or transferred to associate membership. The allowable number of

TEST of WOOD SILL SPLICES

SHEET A

TEST NO	M.C.B. FIGURE	EXCEPTION	SKETCH	KIND OF WOOD IN SILL TOP	SILL BOTTOM	LINER	DIMENSIONS OF SILL	LINER	WEIGHT IN LBS	DROP IN FEET — ONE BLOW FOR EACH HEIGHT. 1	2	3	4	5	6
1	9A	NONE		YELLOW PINE	FIR	OAK	$4\frac{7}{8}'' \times 8\frac{5}{8}''$	$1\frac{15}{16}'' \times 8\frac{7}{8}''$	145	SPLIT AT BOTH BUTTS					
2				YELLOW PINE	YELLOW PINE	OAK	$4\frac{13}{16}'' \times 8\frac{13}{16}''$	$1\frac{15}{16}'' \times 8\frac{7}{8}''$	151	BOTH BUTTS SPLIT FOR SHORT DISTANCE.	BOTH BUTTS CRUSHED, AND SPLIT TO ENDS OF TIMBER.				
3				YELLOW PINE	YELLOW PINE	OAK	$4\frac{3}{4}'' \times 8\frac{13}{16}''$	$1\frac{15}{16}'' \times 9\frac{1}{16}''$	140	SPLIT AT BOTH BUTTS. BOTTOM TIMBER DEFECTIVE					
4				FIR	FIR	OAK	$4\frac{7}{8}'' \times 8\frac{3}{4}''$	$1\frac{15}{16}'' \times 9''$	134	SPLIT AT BOTH BUTTS					
13	9 B	NONE		YELLOW PINE	NORWAY PINE	PINE	$4\frac{7}{8}'' \times 8\frac{3}{4}''$	$2\frac{1}{2}'' \times 9''$	123	OLD CRACK AT TOP BUTT EXTENDED $1\frac{1}{2}$ INCHES.	NO CHANGE	CRUSHED BETWEEN 2ND AND 3RD VERTICAL BOLTS, ON SIDE. SPLIT IN TOP SECTION.	CRUSHED IN THREE PLACES. SPLIT IN TOP AND BOTTOM SECTIONS.		
14				YELLOW PINE	YELLOW PINE	PINE	$4\frac{3}{4}'' \times 8\frac{11}{16}''$	$2\frac{1}{2}'' \times 8\frac{15}{16}''$	146	O.K	O K	O.K	SPLIT AT LOWER END. CRUSHED AT 2ND VERTICAL BOLT. SPLIT BETWEEN TWO CENTER VERTICAL BOLTS.	SHATTERED BADLY BETWEEN BUTTS	
15				FIR	FIR	PINE	$4\frac{13}{16}'' \times 8\frac{3}{4}''$	$2\frac{1}{2}'' \times 9''$	126	SLIGHT SPLIT IN SPLICE NEAR UPPER BUTT	NO CHANGE	NO CHANGE.	SPLIT IN TOP SECTION NEAR BUTT EXTENDED TO END OF TIMBER.	TOP SECTION BADLY CRUSHED. BOTTOM SECTION SLIGHTLY CRUSHED AT BOLT IN SPLICE.	
16				YELLOW PINE	FIR	PINE	$4\frac{7}{8}'' \times 8\frac{7}{8}''$	$2\frac{7}{16}'' \times 9''$	152	O K	O K	O.K.	SLIGHT CRACK IN LOWER SECTION AT BUTT.	CRUSHED ON ONE SIDE, TOP AND BOTTOM	
25	STRAIGHT SILL WITHOUT SPLICE	NONE		YELLOW PINE			$4\frac{15}{16}'' \times 8\frac{15}{16}''$		116	O K	O K	O.K.	SLIGHT SPLIT 18" FROM TOP. OLD CRACK OPENED UP 1 1/2" NEAR TOP. CRUSHED 2 FT. FROM BOTTOM.	SPLIT ENTIRE LENGTH.	
26				YELLOW PINE			$5\frac{1}{16}'' \times 8\frac{3}{8}''$		110	O K	O K	O.K.	CRUSHED SLIGHTLY AT TOP.	CRUSHED AND SHATTERED AT TOP.	
27				FIR			$4\frac{3}{4}'' \times 8\frac{3}{4}''$		84	O K	O K	O.K.	BADLY CRUSHED AND SPLIT AT BOTTOM.		
28				FIR			$4\frac{13}{16}'' \times 8\frac{3}{4}''$		87	O K	O K	O.K	O.K	SHATTERED AT BOTTOM.	
37	9A	VERTICAL BOLT ADDED EITHER SIDE 18" FROM CENTER OF SPLICE		YELLOW PINE	YELLOW PINE	OAK	$4\frac{13}{16}'' \times 8\frac{3}{4}''$	$1\frac{7}{8}'' \times 8\frac{7}{8}''$	141	SPLIT AT BOTH BUTTS	BADLY CRUSHED AT BOTH BUTTS.				
38				YELLOW PINE	YELLOW PINE	OAK	$4\frac{7}{8}'' \times 8\frac{13}{16}''$	$1\frac{15}{16}'' \times 9''$	148	SLIGHT CRACK AT BOTH BUTTS	BADLY CRUSHED AND SPLIT AT BOTH BUTTS.				
43	9A	BOLT OPPOSITE END OF SPLICE LEFT OUT IN EACH END.		FIR	FIR	OAK	$4\frac{7}{8}'' \times 8\frac{7}{8}''$	$2'' \times 9''$	130	SPLIT FROM BOTH BUTTS TO ENDS OF TIMBER.					
44				YELLOW PINE	YELLOW PINE	OAK	$4\frac{7}{8}'' \times 8\frac{3}{4}''$	$2'' \times 8\frac{15}{16}''$	137	SPLIT AT LOWER BUTT	CRUSHED IN SPLICE AND BADLY SPLIT AT LOWER BUTT				
49	8	NONE		NORWAY PINE	NORWAY PINE		$4\frac{7}{8}'' \times 8\frac{13}{16}''$		73	SPLIT AT UPPER BUTT. SPLIT AND CRUSHED AT LOWER BUTT.	BADLY CRUSHED AT BOTH BUTTS.				
50				YELLOW PINE	YELLOW PINE		$4\frac{13}{16}'' \times 8\frac{3}{4}''$		108	SPLIT AT BOTH BUTTS	BADLY CRUSHED AT BOTH BUTTS.				
51				YELLOW PINE	YELLOW PINE		$4\frac{3}{4}'' \times 8\frac{7}{8}''$		98	SPLIT FROM BOTH BUTTS TO ENDS OF TIMBER	CRUSHED IN LOWER SECTION AWAY FROM BUTT				
52				FIR	FIR		$4\frac{7}{8}'' \times 8\frac{11}{16}''$		84	SPLIT FROM BOTH BUTTS TO ENDS OF TIMBER.					
61	8	BUTT SPLICE		YELLOW PINE	YELLOW PINE		$4\frac{13}{16}'' \times 8\frac{11}{16}''$		101	O K	O K	O.K.	LOWER SECTION BADLY SPLIT. UPPER SECTION SPLIT THROUGH BOLTS IN SPLICE.		
62				YELLOW PINE	YELLOW PINE		$4\frac{13}{16}'' \times 8\frac{3}{4}''$		95	O K	SPLIT IN LOWER SECTION DUE TO DEFECTIVE TIMBER.				
63				YELLOW PINE	YELLOW PINE		$4\frac{15}{16}'' \times 8\frac{11}{16}''$		117	O K	O K	SLIVERED AT ONE CORNER OF LOWER SECTION ENTIRE LENGTH.	SPLIT THROUGH VERTICAL BOLTS AND AT LOWER BUTT THROUGH OLD CRACK		
64				YELLOW PINE	YELLOW PINE		$4\frac{3}{4}'' \times 8\frac{9}{16}''$		112	O K	O K	O.K	O.K	O K	UPPER SECTION SPLIT THROUGH VERTICAL BOLTS; UPPER BUTT CRUSHED.
73	9A	LOCATION OF BOLTS CHANGED		YELLOW PINE	FIR	OAK	$4\frac{13}{16}'' \times 8\frac{3}{4}''$	$1\frac{15}{16}'' \times 9''$	134	SPLIT AT BOTH BUTTS	LOWER BUTT BADLY SPLIT				
74				YELLOW PINE	YELLOW PINE	OAK	$4\frac{15}{16}'' \times 8\frac{11}{16}''$	$2'' \times 9''$	143	O K	SHATTERED FROM BOTH BUTT TO ENDS OF TIMBER.				
75				FIR	YELLOW PINE	OAK	$4\frac{7}{8}'' \times 8\frac{13}{16}''$	$1\frac{15}{16}'' \times 9''$	124	SLIGHTLY SPLIT AT BOTH BUTTS.	CRACKS EXTENDED AND BOTH BUTTS CRUSHED.	BADLY CRUSHED AT BOTH BUTTS.			
76				YELLOW PINE	NORWAY PINE	OAK	$4\frac{15}{16}'' \times 8\frac{11}{16}''$	$1\frac{15}{16}'' \times 9''$	150	SLIGHTLY SPLIT AT BOTH BUTTS.	CRACKS EXTENDED TO ENDS OF TIMBER. SHATTERED ON ONE SIDE IN UPPER SECTION.				
77				FIR	FIR	OAK	$4\frac{15}{16}'' \times 9''$	$2'' \times 9''$	121	SLIGHTLY SPLIT AT BOTH BUTTS.	BADLY SPLIT AND CRUSHED AT BOTH BUTTS.				
78				FIR	FIR	OAK	$5'' \times 8\frac{13}{16}''$	$1\frac{15}{16}'' \times 9\frac{1}{16}''$	124	SLIGHTLY SPLIT AT UPPER BUTT.	CRACK EXTENDED AT UPPER BUTT. BOTH BUTTS SLIGHTLY CRUSHED.	BOTH BUTTS CRUSHED. UPPER BUTT BADLY CRUSHED.			

SUPPORTS 7 FT. APART FOR TEST OF SPLICES.
SUPPORTS 40 FT. 6 IN. APART FOR TEST OF LINERS

TRANSVERSE TEST OF WOOD SILL SPLICES

SHEET G

TEST NO.	M.C.B. FIGURE	EXCEPTION	SKETCH	KIND OF WOOD IN SILL		KIND OF WOOD IN LINER	DIMENSIONS OF SILL	DIMENSIONS OF LINER	WEIGHT IN LBS.	DEFLECTION AT LOAD OF LBS. 5.000	DEFLECTION AT LOAD OF LBS. 10.000	MAX. LOAD	DESCRIPTION OF FAILURE
5	9A	NONE		YELLOW PINE	YELLOW PINE	OAK	$4\frac{13}{16}'' \times 8\frac{11}{16}''$	$2'' \times 8\frac{15}{16}''$	141	.40	1.07	14,470	FAILED AT CENTER OF SPLICE
6				YELLOW PINE	YELLOW PINE	OAK	$4\frac{13}{16}'' \times 8\frac{3}{4}''$	$1\frac{15}{16}'' \times 8\frac{15}{16}''$	142	.32	1.04	11,970	POOR LINER
7				FIR	FIR	OAK	$4\frac{7}{8}'' \times 8\frac{13}{16}''$	$1\frac{15}{16}'' \times 9\frac{1}{16}''$	125	.305	.88	13,500	FAILED AT CENTER OF SPLICE
8				YELLOW PINE	YELLOW PINE	OAK	$5'' \times 8\frac{7}{8}''$	$2\frac{1}{16}'' \times 9\frac{1}{16}''$	143	.24	.70	16,700	FAILED AT CENTER OF SPLICE
17	9B	NONE		YELLOW PINE	YELLOW PINE	PINE	$4\frac{15}{16}'' \times 8\frac{7}{8}''$	$2\frac{1}{2}'' \times 9''$	144	.22	.53	17,980	LINER CRACKED AND ONE SECTION FAILED NEAR END OF SPLICE
18				FIR	FIR	PINE	$4\frac{3}{4}'' \times 8\frac{3}{4}''$	$2\frac{9}{16}'' \times 9''$	132	.255	.59	17,870	FAILED NEAR END OF SPLICE
19				YELLOW PINE	YELLOW PINE	PINE	$4\frac{7}{8}'' \times 8\frac{3}{4}''$	$2\frac{1}{2}'' \times 9\frac{1}{16}''$	143	.24	.58	14,000	FAILED AT VERTICAL BOLT IN END OF SPLICE
20				YELLOW PINE	YELLOW PINE	PINE	$4\frac{15}{16}'' \times 8\frac{11}{16}''$	$2\frac{7}{16}'' \times 9''$	160	.23	.54	14,890	FAILED AT ONE END OF SPLICE
29	STRAIGHT SILL	NONE		YELLOW PINE			$4\frac{15}{16}'' \times 9''$		68	.15	.33	14,000	BROKE THROUGH SUN CRACK
30				YELLOW PINE			$4\frac{7}{8}'' \times 8\frac{7}{8}''$		97	.14	.28	24,480	SPLIT FROM CENTER TO ONE END
31				YELLOW PINE			$4\frac{7}{8}'' \times 8\frac{11}{16}''$		93.	.12	.24	24,000	FAILED NEAR CENTER
32			8'0"	FIR			$4\frac{27}{32}'' \times 8\frac{9}{16}''$		83	.10	.23	24,000	SPLIT FROM CENTER TO ONE END
SEE SHEET B FOR CURVES OF ABOVE TESTS													
39	9A	VERTICAL BOLT ADDED EITHER SIDE 18" FROM CENTER OF SPLICE		YELLOW PINE	YELLOW PINE	OAK	$4\frac{7}{8}'' \times 8\frac{3}{4}''$	$2'' \times 9''$	148	.24	.69	14,130	FAILED AT CENTER OF SPLICE
40				FIR	FIR	OAK	$4\frac{13}{16}'' \times 8\frac{13}{16}''$	$2'' \times 8\frac{15}{16}''$	122	.365	.97	11,000	FAILED AT CENTER OF SPLICE
45	9A	BOLT OPPOSITE END OF SPLICE LEFT OUT IN EACH END		FIR	FIR	OAK	$4\frac{25}{32}'' \times 8\frac{7}{8}''$	$2'' \times 8\frac{7}{8}''$	135	.26	.65	14,980	VERTICAL BOLT AT ONE END OF SPLICE BROKE
46				YELLOW PINE	YELLOW PINE	OAK	$4\frac{13}{16}'' \times 8\frac{11}{16}''$	$1\frac{15}{16}'' \times 8\frac{15}{16}''$	125	.31	.77	13,000	ONE SECTION BROKE AT CENTER OF SPLICE
SEE SHEET C FOR CURVES OF ABOVE TESTS													
22	9B	LINER AND OUTSIDE VERTICAL BOLTS REMOVED	REMOVED FOR TEST 22	FIR	FIR		$5'' \times 8\frac{13}{16}''$		89	.57		8,400	FAILED OUTSIDE OF SPLICE
23		LINERS REMOVED		YELLOW PINE	YELLOW PINE		$4\frac{15}{16}'' \times 8\frac{7}{8}''$		104	.66		5,900	FAILED IN SPLICE NEAR END
24				FIR	FIR		$5'' \times 8\frac{7}{8}''$		79			4,800	FAILED IN SPLICE NEAR END
53	8	NONE		FIR	FIR		$4\frac{27}{32}'' \times 8\frac{3}{4}''$		88	.54		7,600	FAILED AT CENTER OF SPLICE
54				YELLOW PINE	YELLOW PINE		$4\frac{3}{4}'' \times 8\frac{11}{16}''$		103	.50		7,900	FAILED AT CENTER OF SPLICE
55				FIR	FIR		$4\frac{7}{8}'' \times 8\frac{13}{16}''$		93	.43		9,850	FAILED AT CENTER OF SPLICE
56				YELLOW PINE	YELLOW PINE		$4\frac{7}{8}'' \times 8\frac{11}{16}''$		112	.55		6,800	FAILED AT CENTER OF SPLICE
65	8	BUTT SPLICE		FIR	FIR		$4\frac{13}{32}'' \times 8\frac{11}{16}''$		99	.78		5,900	FAILED NEAR END OF SPLICE
66				YELLOW PINE	YELLOW PINE		$4\frac{13}{16}'' \times 8\frac{3}{4}''$		106	.56		9,000	FAILED NEAR END OF SPLICE
67				FIR	FIR		$4\frac{13}{16}'' \times 8\frac{13}{16}''$		80	.66		6,870	FAILED NEAR END OF SPLICE
68				YELLOW PINE	YELLOW PINE		$4\frac{15}{16}'' \times 8\frac{13}{16}''$		115	.50	1.98	10,000	FAILED NEAR END OF SPLICE
SEE SHEET D FOR CURVES OF ABOVE TESTS													
	3 OAK LINERS		SEE CURVE SHEET				$5\frac{7}{8}'' \times 9''$		114	.03	.07	50,250	SPLIT AT BOTH ENDS
	3 PINE LINERS						$7\frac{3}{16}'' \times 9''$		102	.03	.06	42,950	SPLIT AT BOTH ENDS
SEE SHEET E FOR CURVES OF ABOVE TESTS													

associate members was increased from twenty to fifty. Another important addition was the following: "Subjects involving legal, transportation, permanent way or traffic questions, or for any other reason requiring such action, may be submitted as recommendations to the American Railway Association."

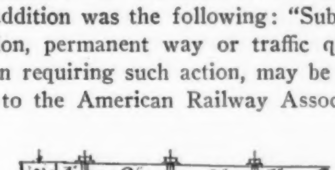


FIG. 8

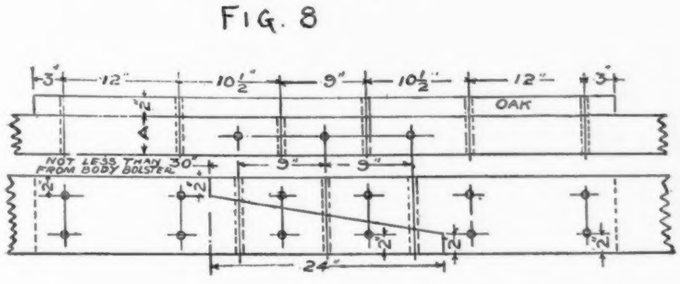


FIG. 9-A

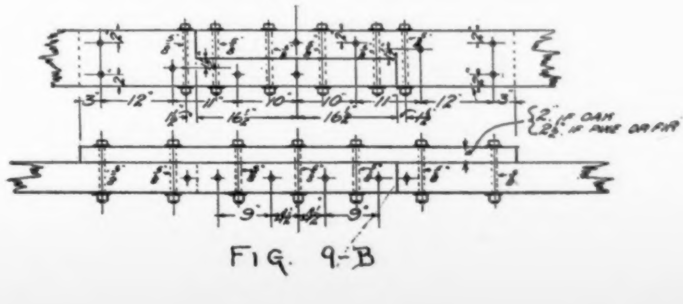


FIG. 9-B

SPLICING SILLS.

Committee: R. E. Smith, Chairman; W. F. Bentley, I. S. Downing, H. L. Trimyer, F. A. Torrey.

The committee concluded that, to thoroughly investigate this subject, it would be necessary to submit to drop tests a number of sills spliced in accordance with each of the two styles permitted by the Rules of Interchange, in order that conclusions might be drawn from average results, and that transverse and tensile tests should be included. It was considered wise to make similar tests upon variations in the standard splice, in the hope that this procedure would throw additional light upon the subject. The tests were made in the presence of the full committee at the C. B. & Q. Railroad Company's laboratory, Aurora, Ill. The test samples were eight feet in length and were made from select second-hand, sound 5 by 9-inch car sills.

DROP TESTS.

These tests were made on M. C. B. drop machine and represent conditions that cause the largest number of failures to sills in service. The test was started, using a one-foot drop, and with each succeeding drop raising the distance one foot. Data sheet "A" shows results of these tests. Comparing results of tests 1 to 4 representing splices per Fig. 9-A; tests 13 to 16, representing splices per Fig. 9-B; and tests 25 to 28, which were made with straight sills without splice, we get the following:

Figure	9-A		9-B		Straight Sill	
	Test No.	Failed at drop of	Test No.	Failed at drop of	Test No.	Failed at drop of
	1	1'	13	3'	25	4'
	2	1'	14	4'	26	4'
	3	1'	15	4'	27	4'
	4	1'	16	4'	28	5'
Average Drop		1'		3.75'		4.25'
Strength compared with straight sill		23.5%		88%		100%

This shows that the splice made as per Fig. 9-B will stand 88 per cent. of the abuse that solid sills will stand, while the splice

made as per Fig. 9-A will stand only 23.5 per cent. of the abuse that the solid sill will stand. Comparing the two kinds of splices, the splices Fig. 9-B are 375 per cent. stronger than Fig. 9-A.

The weak place in the splice Fig. 9-A is the small cross-section at the ends; with splice Fig. 9-B we get practically the solid timber to withstand the blows which occur in the bumping of cars.

TRANSVERSE TESTS.

These tests were made with supports seven feet apart. The splices made to Fig. 9-A give the largest deflections, while the straight sill gives the least deflections. The results are shown in the accompanying table (curves in report are not reproduced).

TENSILE TESTS.

(Curves in report not reproduced.)

These tests show in favor of the splice made as per Fig. 9-B.

SUMMARY.

A comparison of tests indicates that there is very little, if any, strength added to the butting resistance of splice 9-A by the side plank and that this form of splice is not appreciably improved by the addition of the vertical bolts 18 inches each side of the center of the splice, nor by the omission of one of the horizontal bolts near each butt of the splice.

In fact, all forms of the scarfed splice failed under very much less severe butting strains than the square butt splice; the weakness of this splice is due, in the judgment of the committee, to the fact that pressure or a blow upon the end of the sill causes the inclined surfaces of the scarf to slide sufficiently upon each other to interlock the fibers of the sills at the shoulders.

As it is not usual, if not impracticable, under the conditions under which splicing of freight-car sills is usually done, to fit them up without a certain amount of slack in the bolt holes and at the shoulders, the movement described above probably takes place under comparatively light butting shocks, and it could not be altogether prevented by the use of tightly fitting bolts and superior workmanship on account of the compression of the timber around the bolts and the small areas of the shoulders.

As the movement is continued, the two members of the splice tend to slide up, over and past each other, tearing loose by a lifting movement the upper portion of the sill, which splits along the grain, starting invariably at the base of the shoulders. Any further movement results in buckling the detached portion or in shattering it.

It is clear that the weakest form of splice would be that with a plain scarf, without shoulders; a similar splice with shoulders of small area would be stronger than the plain splice under butting or compressive strains; with shoulders of still larger area, the splice would be still stronger, and so on until a form of splicing, having shoulders of combined area equal to the full cross section of the sill, is evolved; splice 9-B is such a splice. This form of splice, then, logically, is the strongest, and under the drop tests, conducted by the committee, it was proven to be.

Supplementing the above, the committee desires to call attention to the report of the Committee on Splicing Passenger Car Sills, made at the convention of 1902; that committee arrived at virtually the same conclusions as the present committee, regarding the superiority of the butt splice under compression; the photographs contained in that report indicate that the various forms of scarfed splices failed in identically the same manner as those tested by the present committee; the brevity of the discussion following the presentation of that report indicates little interest on the part of the members, and when the recommendation of the committee that the butt or step splice be adopted as Recommended Practice in splicing passenger-car sills was submitted to a letter ballot, it lacked 37 of receiving the required number of votes (682), the count showing affirmative 645, negative 378.

The graphic records of the behavior of the two forms of splice under investigation, when subjected to transverse strains, indicate convincingly the superiority of splice 9-B over 9-A. As the strength of both forms is in excess of the transverse strains developed under the worst possible conditions met with in service, the series of transverse tests are not considered of special importance, and merely accentuate the results derived from the drop tests.

The transverse tests of the side planks, however, considered in connection with similar test of the splices without the reinforcing side planks, show the large part the former play in stiffening both forms of splices, 9-A and 9-B.

When subjected to tensile strains, the behavior of both forms of splice the committee was instructed to investigate was practically uniform under such strains as are probably developed in actual service; whatever difference there appears to be in the strength of the two samples is probably accidental and due to workmanship, difference in compression around bolts, friction between parts, and not to any difference in form.

While the committee felt that the subject assigned to it was of sufficient importance to warrant it in extending its investigations outside of the limits prescribed in its instructions, making tests of various modifications of both forms of splice prescribed by the Rules of Interchange, in the hope that all possible light might be shed on the subject, yet it realized from the beginning that the ability to resist butting or compression strains would be the chief consideration in determining the comparative merits of the two forms of splice under investigation.

The butt splice has a further advantage over the scarf splice, arising out of the greater ease with which it can be framed without removing the sound portion of the sill from the car, and some lines, for this reason, allow a lower piece-work price for the butt than for the scarf splice. It is believed that as great skill is not required to frame the butt as the scarfed splice, and that, therefore, this class of work can be done at such points and under such conditions as would not admit of the use of the scarfed splice. The committee unanimously recommends, for work to be done after September 1, 1909:

1. That splice 9-B be adopted as standard for the splicing of center or draft sills of freight cars.

2. That five-eighths of an inch in diameter for bolts and eleven sixteenths of an inch for bolt holes be adopted as standard in assembling sill splices of freight cars.

3. That the butt, or step splice, without side plank, be adopted as standard for the splicing of all freight car sills, other than center or draft sills.

SALT WATER DRIPPINGS FROM REFRIGERATOR CARS.

Committee:—M. K. Barnum, chairman, G. W. Lillie, W. E. Sharp, E. W. Pratt, P. Maher, D. C. Ross, W. C. Arp.

At the convention of 1898 a committee reported on this subject as follows:

1. "That more interest is being taken in the subject by the officials in charge of the track and bridges than by those in charge of rolling stock, which is accounted for by the fact that the track and bridges are being more damaged by salt-water drippings than the car trucks."

2. "That in refrigerator cars loaded with dressed beef the mixture used for cooling purposes is composed of ice and salt, the proportion of the salt to the ice varying from 6 to 11 per cent."

3. "That one refrigerator car will produce about 200 gallons of salt water or brine every twenty-four hours, which, on an average, will contain 8½ per cent. of salt."

The committee at that time started out with the idea of having refrigerator cars fitted with one or more reservoirs, to be attached underneath the car body, into which the salt-water drippings could be conveyed, the reservoirs to be large enough so that they would not have to be emptied more than once every twelve hours at terminals where proper provision could be made for taking care of the salt water, but the idea met with so much opposition that the committee abandoned it, and recommended two methods of allowing the water to drip in the center of the track, one of which was adopted by the Association as recommended practice, and is shown on Sheet M. C. B.—A, Proceedings, 1907.

The appointment of a committee to reconsider this question would indicate, first, that the complaints of damage to track, bridges, etc., have continued, and with increasing force, and, second, that the recommended practice has not been found satisfactory. Sufficient evidence has been collected by the committee to convince any fair-minded person beyond question that the drippings from refrigerator cars using salted ice do serious damage to the rails and fastenings, bridges and other metal parts pertaining to the roadway, in proportion to the amount of this kind of business handled; the damage being greatest on elevated curves, at coaling and water stations, and other localities where such cars are started and stopped.

The committee finds that the present recommended practice has only been used experimentally on a few cars, which developed the following objections:

1. The numerous turns in the pipes prevent cleaning out sawdust and other obstructing matter.

2. The pipes freeze in cold weather.

3. The location is such that the pipes are easily torn off by the brake rigging.

The committee therefore concludes that the device shown on Sheet M. C. B.—A is unsatisfactory and impracticable, but favor retaining it pending investigations and tests now under way. The committee has done some experimental work which does not yet justify drawing conclusions, but it is being continued with the expectation that during the coming year the tests will be completed, and definite recommendations made.

Three methods have been suggested for taking care of salt-water drippings.

1. Tanks located inside of the car, below the ice tanks, to catch and retain the drippings until arrival at an inspection point, where they could be drained.

2. Tanks suspended underneath the car between the trucks.

3. That drippings be conducted to a narrow pathway alongside the track at the ends of the ties and so scattered that they

will do the least damage, and that the roadbed be given special attention at this point, about four feet or four feet six inches from center of track, to provide against this damage. This is a modification of the present practice and probably will not meet the approval of the maintenance of way department.

The principal objections raised to the first two of these plans are that they would cause serious delays to refrigerator trains in yards where the draining of the tanks is to be done. The handling of refrigerator products is essentially a main line business, similar to passenger service, and any delays incident to the transfer of such business to a switch track with drains for receiving the salt water would not be tolerated by transportation officials. Another objection to such systems would be the necessity for installing a system of conduits for carrying off the salt water.

The first plan is also open to the following objections: The use of water tanks inside the car would necessitate reducing either the size of ice tanks or the space for the revenue load, because refrigerator cars are now built to receive an exact number of cases of a standard size and any encroachment on this space will reduce the carrying capacity of the car. The successful transportation of meat products requires a constant or gradually lowering temperature in the car. The use of such tanks inside of the car might have a tendency to increase the temperature, thereby affecting the condition of the contents on arrival at destination. The location of tanks inside of car would also make it more difficult to repair draft rigging and sills.

The second plan suggested would only be usable during warm weather, because the pipes would freeze in winter. Furthermore, the space underneath a refrigerator car is now so taken up with trucks, brakes, needle beams, truss rods, etc., that it would be difficult to find space for tanks which must hold at least 200 gallons.

All three of these plans are being studied in detail with the view of determining their cost and testing their efficiency. If any of the members have other suggestions for disposing of salt-water drippings, the committee will be glad to consider them. It has been impossible to make all desired tests in time for this convention and the committee would therefore recommend that the subject be continued so that the work, as outlined, can be completed.

Discussion.—The committee made some tests, after the report was printed, retaining the salt water in the ice tanks. The tests were made on refrigerator cars standing in the shops of the Armour Car Lines. In both tests the overflow pipes were closed and all the brine retained in the ice tanks during the entire test.

The first test covered a period of four days, during which time the outside temperature varied from a minimum of 49 deg. to a maximum of 79 deg. The first icing reduced the temperature of the car to about 35 deg. within 5 hours. The car was again iced after about 20 hours and the temperature reduced to below the freezing point and maintained there for three days by means of re-icing at intervals of 24 hours.

The second test extended over a period of four and one-half days, during which the outside temperature varied between 50 deg. and 80 deg. In this test the temperature reduced more slowly, but was kept below freezing for three days. After about 48 hours it gradually increased, in spite of several re-icings, to about 32 deg. at the end of test, indicating that after the brine has absorbed a certain amount of heat, it must be discharged from the tanks in order to maintain the necessary degree of refrigeration.

To definitely determine whether this plan of retaining the brine in the ice tanks and draining it off at regular icing stations will work satisfactorily, it will be necessary to make additional standing tests and then to make road tests with cars under load during hot weather.

Action.—The report was received and the committee continued.

PAINTING STEEL CARS.

Committee: G. E. Carson, Chairman; T. Rumney, G. A. Schmoll, J. M. Shackford, J. T. Wallis.

Last year the committee made a report of progress and reported a number of cars under test, also a few recommendations; we can see no reason why the former recommendations should be changed. They are as follows: Suitable buildings should be provided for the painting of cars, so that the painting of the equipment would not necessarily be confined to certain seasons of the year, for it is essential that the equipment, regardless of the season, be well covered with a protective coating, in order to arrest deterioration, which otherwise is very rapid.

In the preparation of the assembled parts of new cars they should not be exposed to the weather or permitted to rust before their assemblage. In all cases where metal is placed against metal, either riveted or bolted, it should be free from flash or rust and covered with one or two coats of red lead, and the mixture be heavy enough to exclude moisture, but this protection will avail little unless extra care is taken that all the steel parts fit evenly and are applied in like manner.

After cars are ready for the first coating it is necessary that all flash and rust be removed. This should be done under rigid inspection. Unless the flash is removed it will invariably fall off inside of one year and continue as long as any remains, regardless of the number of coats of paint applied. It is recommended that flash and rust be removed by sand blast, where possible. Would next recommend dry cleaning (which we do not believe so satisfactory), by using steel scratch brushes, sandstone or any tools which will answer the purpose, being particular to remove all the dust with suitable brushes or dusters. After following either of these cleanings we suggest the application of three coats of paint at twenty-four hour intervals. In the preparation of cars for repainting we again recommend cleaning by sand blast, but if this cannot be done under all conditions, then use the dry cleaning process, as previously mentioned. After the dry cleaning we would recommend two coats of standard paint applied at twenty-four hour intervals. We cannot be too emphatic as to the necessity of taking the proper care of the exterior, and regret that we are not able to give the interior the same care.

The committee has examined a number of cars under test which were in ordinary service; the results of the various tests are as follows:

One car, thoroughly dry cleaned and given two coats of a special black paint, was then coated over with crude petroleum oil. After fifteen months' service it was found that the painted surface of the car was in fine condition, and there was a showing of the crude oil still clinging to the paint surface.

One car, thoroughly dry cleaned and given two coats of a special black paint, was then coated over with locomotive cylinder oil. After fifteen months' service it was found that the painted surface of the car was in fair condition. We are inclined to believe that the application of the locomotive cylinder oil had a tendency to extend the elastic life of the paint.

One car, thoroughly dry cleaned and given two coats of a special black paint, was then coated over with a good quality of fish oil, applied with brush. After being in service fifteen months the condition of the paint was very fine indeed, but there was no indication of the surface oil at time of inspection.

One car, thoroughly dry cleaned and given two coats of common red car paint generally used by railroads, was then covered with equal parts of raw linseed oil and pure glycerin. After being in service fifteen months, it proved to be the slowest in drying. The painted surface was in good condition.

One car, thoroughly dry cleaned and painted with two coats of common red car paint generally used by railroads, was then given a coating of "Cleanola." After being in service fifteen months the paint was found to be in fair condition. It also shows some preservation.

One car, thoroughly dry cleaned and given two coats of common red car paint generally used by railroads, was then covered with a coat of well-rubbed-in commercial tallow. After this car had been in service fifteen months the paint was found to be in fair condition, but no traces of the overcoat of tallow remained.

One car was thoroughly dry cleaned and covered with two coats of a special black paint. (No preservative applied.) After being in service eight months the paint was found in remarkably good condition, notwithstanding the fact that there appeared to be much material brittleness, also loss of weight in scrapings.

One car, thoroughly dry cleaned and given two coats of a special black paint, was covered with a special manufactured over-oil. After being in service eight months the paint was found to be broken in places, and scrapings appear to be soft, broken and tacky.

Six cars were thoroughly cleaned out on the inside, and with an atomizing machine were given two coats of crude petroleum oil. After being in service fifteen months the interior was examined. To the eye and touch these surfaces did not give the slightest indication of the previous bountiful oil coating. Inspection convinced us that if this treatment acts as a preservative in any form the insides should be treated at least every six months.

The committee at the present time has under test twenty-five steel cars which have had the insides sand-blasted and the seven following mixtures applied heavily and not brushed out:

No. 1	Petrolatum	30 pounds
	Raw linseed oil	210 pounds
No. 2	Petrolatum	30 pounds
	Corn oil	210 pounds
No. 3	Petrolatum	30 pounds
	Crude oil	210 pounds

No. 4	Tar	30 pounds
	Aniline oil	40 pounds
	Corn oil	170 pounds
No. 5	Tar	30 pounds
	Aniline oil	40 pounds
	Raw linseed oil	170 pounds
No. 6	Tar	30 pounds
	Aniline oil	40 pounds
	Portland cement	30 pounds
	Corn oil	140 pounds
No. 7	Tar	30 pounds
	Aniline oil	40 pounds
	Portland cement	30 pounds
	Raw linseed oil	140 pounds

Two cars bearing mixture No. 1 were examined after being in service four months and twenty-nine days and were found to have the sides and ends in fair condition, but the paint was gone from the bottom, and no scale accumulated on the inside of the car.

One car bearing mixture No. 2 was examined after being in service four months and twenty-six days and was found to have the sides and ends fairly well preserved, but the paint gone from the bottom and no accumulation of rust.

Two cars bearing mixture No. 3 were examined after being in service four months and twenty-one days and showed the sides and ends somewhat protected, but considerable rusting going on. This mixture did not retard rusting as well as mixtures Nos. 1 and 2.

One car bearing mixture No. 4 was examined after being in service four months and seventeen days and showed the inside well preserved, but considerable of the paint gone from the bottom, yet there seemed to be retardation of the rusting, and no accumulation of scale. This mixture shows better results than mixtures Nos. 1, 2 and 3.

One car bearing mixture No. 7 was examined after being in service four months and showed the sides well preserved, but the bottom somewhat rusted. This car was in a better condition than any of the other cars inspected and would indicate that No. 7 mixture is preferable and would be especially valuable from the tests so far made. To get the best results from a coating of this kind, one coat should be applied about once every six or eight months.

However, it is not fair for us to draw a conclusion as to which of these inside mixtures is the best, for the reason that the cars have not been in service long enough to determine this feature. Until these inside mixtures are thoroughly tested out the committee is not in a position to recommend their use. The committee realizes the necessity of a continuation for another year, in order to further determine the results of the tests now being made. The desire is to give the Association, in the final report, a formula for the inside and outside coating of steel cars.

Discussion.—It developed that the cars under test were all-steel hoppers and gondolas which had previously been in service two or three years. Before being covered with the test paint they were sand blasted. The paint was applied in the open and under favorable weather conditions.

It seems to be impossible to get a preservative for the inside of the car. There is very little deterioration in the inside when the cars are kept in constant service, but, as stated by Mr. Carson, one month idle is equal to two or three years in service as far as deterioration is concerned. Rust should not be removed from the inside of the car as it protects the metal from further corrosion. It was suggested that the committee in carrying on its work confer with the American Society for Testing Materials, which is making extensive tests along these lines.

Action.—The recommendations of the committee were adopted and it was continued for another year.

SAFETY APPLIANCES.

Committee—C. A. Seley, Chairman; A. LaMar, T. H. Curtis, C. B. Young, LeGrand Parish, H. Bartlett, T. M. Ramsdell.

In the first place, we would call attention to the misleading title of this committee, which, by instruction, confines its work to those standards formerly designated "for the Protection of Trainmen." Safety appliances are generally considered to include the fixtures on cars which are referred to in the Safety Appliance Acts, and embrace the air brakes, coupler and unlocking attachments in addition to the handholds, steps, etc. Two other standing committees have these matters in hand, so that this committee has not supervision over all that its title would imply. This is not generally understood, as was proven by the receipt of several communications from members in reference to matters outside of our supervision.

The result of the letter ballot of 1908, being so overwhelmingly in favor of the adoption of the standards as proposed by the special committee reporting to the last convention, was an indication that they were so favorably considered that very little revision would be suggested, and we have to report very few answers to our circular of inquiry sent out September 10, 1908. The cordial support of the committee's report indicated a belief that the revision had not departed from the spirit and intent of the old standards, but that they had been clarified as to language and expression and extended on proper lines to cover the developments in car types and construction not existing when the standards were first promulgated. The practically unanimous ballot also proves the wisdom shown by those originating and building up these standards, which are now the expression of an expert, authoritative body, the weight of whose opinion should be most carefully considered.

A very significant indication of the status of the M. C. B. standards is shown in an executive order issued by the President of the United States, dated January 6, 1909, extending to the Canal Zone and the railways in navy yards, docks, and government property, requiring that the various appliances for the protection of trainmen, as designated in existing standards of the Master Car Builders' Association, shall be used on all freight cars in above described territory. The date of this order was subsequent to that of the letter ballot, so that the standards referred to are the present standards, and if they are good law in Panama and other Government property, they should be equally so in these United States and in every State, State laws and individual opinions to the contrary, notwithstanding.

Our standards have always permitted substitutions for handholds, extending their function to the coupler unlocking rod, lower rounds of ladders, brake-step brackets, etc. The opinion of the Association in this respect has been sustained in a recent United States Court proceeding. Judge Dodge, in the District Court of Massachusetts, in the case of the United States vs. Boston & Maine Railroad, in his charge to the jury used the following language in reference to end handholds on a box car as required by Section 4 of the Safety Appliance Act:

"Now, taking that section as it stands, and giving due weight to the language in which the requirements are expressed, we have to consider just what they mean as applied to the question arising in this case, and I shall instruct you, gentlemen, that Section 4 requires secure grabirons or handholds at those points on the end of each car where they are reasonably necessary in order to afford to men coupling or uncoupling cars greater security than would be afforded them in the absence of any grabiron or handhold at that point or of any appliance affording equal security with a grabiron or handhold. If at any place on the end of this car there was not a grabiron or handhold, properly speaking, but some other appliance, such as a ladder or brake lever, or whatever else you please, which afforded equal security with a grabiron or a handhold at that point, then I shall instruct you that the law has not been violated so far as a grabiron or a handhold at that point is concerned. Having something there which performs all the functions of a grabiron or a handhold is just the same thing as having what is properly called a grabiron or a handhold at that point. It may not be possible to say that a coupling lever or a ladder is a grabiron or a handhold, but if it affords the same security to a man who may need to use one that a grabiron or a handhold, properly speaking, would afford, then, in my judgment, the statute has not been violated."

It was the Master Car Builders' Association that originally affirmed these substitutions as early as 1896, and by almost unanimous letter ballot extended the principle of substitution to apply to the platform posts and railing of open platform passenger train cars and cabooses as effective handholds in 1908. The application of handholds to such platform cars is certainly not in accord with M. C. B. standards; practical trainmen do not want them, and it is difficult to understand why some roads are applying them, unless to fulfil a strictly technical interpretation of the law, which is contrary to the opinion held by Judge Dodge, as quoted above.

Several members have written this committee regarding the use of the coupler unlocking rod as an effective handhold. We would reply that, with proper clearance, it is just as much of an M. C. B. standard as any which are included under that title and should be so held until the courts require otherwise. There are several fundamental questions to be adjudicated before a full understanding of the statutes is arrived at and this substitution theory is one of them.

Two or more devices for the same purpose are not desirable for economic reasons, and their presence leads to an uncertainty in time of need, which is not present if a single device only is available. Something to grab quickly and surely will give confidence, and if handholds are added where there is already an efficient substitute, it crowds the location and distracts the attention, so that accidents are more likely to occur than if they were omitted.

Several members urge the abolition of lag screws as fasteners for handholds and steps. Your committee has very carefully considered this question, but can not approve the suggestion. A lag screw properly applied is undoubtedly a secure fastening.

It is quite true that with less care in the application lag screws may be less safe than bolts, although no fastening, whether bolt, lag screw or rivet, may be deemed safe unless properly applied. Many roads are discontinuing the use of lag screws and in repairs are replacing them with bolts with nuts outside wherever practicable. There are, however, some locations that a bolt for fastener is almost prohibitive on account of construction details, and if the standards required bolts "wherever practicable," a question would frequently be raised as to the practicability, whereas the true question is as to whether the lag screw was properly applied. There is nothing to prevent roads making the change on their own cars from lag screw securing to bolt securing for safety appliances; and, if this is done by the roads desiring the discontinuance of the use of lag screws, it will greatly reduce the number of lag screws in use.

In answer to the circular of inquiry, asking for suggestions as to revision, a number of communications were received and considered, and the committee submitted its decisions to the association for approval.

TESTS OF BRAKE SHOES.

Committee:—W. F. M. Goss, Chairman; B. D. Lockwood, William McIntosh.

By agreement, soon after notice of the committee's appointment was received, an outline of the work which should be undertaken was framed and approved. This outline, together with an estimate of the expense which would be involved by its execution, was submitted to the secretary for the executive committee. Formal authority to proceed with the execution of the full program was received November 25, 1908. This program is as follows:

1. To hold a meeting not later than October 10, 1908, at some point such as Cleveland, Indianapolis or Chicago, where considerable numbers of freight cars are handled. To select from freight cars, in coöperation with local railway officials, not less than twenty partially-worn shoes. In making a selection the committee shall seek to secure shoes which are representative of those used by the railroads of the country. The shoes selected shall be numbered, and the terms to be employed in designating them shall be determined by the committee prior to its adjournment.

2. Of the twenty shoes selected, ten shall be sent to the American Brake Shoe Company in care of F. W. Sargent, consulting engineer, with the request that said company test them for the committee, said company having already expressed its willingness to serve the committee by such service. Ten shoes shall also be sent to the Master Car Builders' Laboratory, Purdue University, in care of Dean C. H. Benjamin, to be tested under the immediate direction of the committee.

3. Each shoe shall be tested both upon a cast-iron wheel and upon a steel-tired wheel. Each shoe shall be tested, first, under the Master Car Builders' specifications governing frictional qualities, after which it shall be tested to determine its wearing qualities under the code proposed by the committee in its report to the Association in June, 1908.

4. Following a suggestion of the committee at the last convention to the effect that provision should be made for determining the wearing effect of the brake shoe upon the wheel, the William Sellers Company, of Philadelphia, has been requested to outline a simple form of weighing lever of sufficient capacity to handle a car wheel, and of such delicacy as will serve to detect differences in weight as small as 1/500 of a pound. It is hoped that by the aid of such a device, weighings can be made of the test wheel before and after the wearing test of each brake shoe, and that the loss of weight sustained by the wheel in the process may be determined with a sufficient degree of accuracy to disclose the rate of wear of the shoe upon the wheel. If the executive committee should think it wise to add to the equipment of its laboratory such a weighing device, the committee will make its study of the twenty shoes selected for test include a study of the wearing effect of these shoes upon the wheels to which they are applied. The authorities of Purdue University agree to receive and to install the proposed weighing device in case the executive committee sees fit to provide for it.

5. At the conclusion of the work outlined all results of tests, both those obtained by the American Brake Shoe Company and those obtained by the committee at the laboratory at Purdue University, are to be brought together into one complete record. Upon the facts presented by this record, it is proposed to base a formal specification covering the wearing qualities of brake shoes. The committee may also consider whether there should be any change in the present specifications governing frictional qualities.

6. It is the opinion of the committee that if this outline is successfully carried out, the research work of the brake shoe committee may cease for some years to come.

Proceeding under this program, the committee in January personally selected fourteen brake shoes from cars in service in the Chicago yards of the Chicago & North-Western Railway; and by the aid of others it has since received fourteen additional shoes also taken from cars in service. These twenty-eight shoes are of fourteen different kinds, each kind in duplicate. They have been selected as representative of brake shoes now in use by the railroads of the country. It is proposed that these shoes shall be subjected to the tests outlined above.

It will be noted that the committee now considers its principal work to be the determination of the wearing qualities of shoes and the determination of the effect of the shoe upon the wear of the wheel. The determination of wheel wear requires a weighing device of unusual sensitiveness. Negotiations for a scale designed for this purpose were entered into as early as June 30 of last year with the William Sellers Company, of Philadelphia, and the order for the scale was placed as soon as the executive committee had approved the program as given above. The scale thus provided for has not yet been delivered, and as a consequence it has been impracticable to proceed in the working out of the program. The delay in the manufacture of this apparatus has grown out of the fact that the problem of constructing a device of sufficient capacity to receive a car wheel and sufficiently sensitive to detect differences of one five-hundredth of a pound has proved more difficult than was anticipated, and changes in the preliminary design have been necessary. Responsibility in all such matters is with the manufacturer, and the committee finds satisfaction in assurances received that the completed scale will soon be delivered.

In view of these facts the committee would ask that it be continued for one year, and that its budget, already approved, be allowed to stand, all in the expectation that its program of work can be completed prior to the 1910 convention.

Discussion.—The scale for weighing the wheels has been received and Prof. Endsley reported that it is possible to weigh them accurately within one-thousandth of a pound.

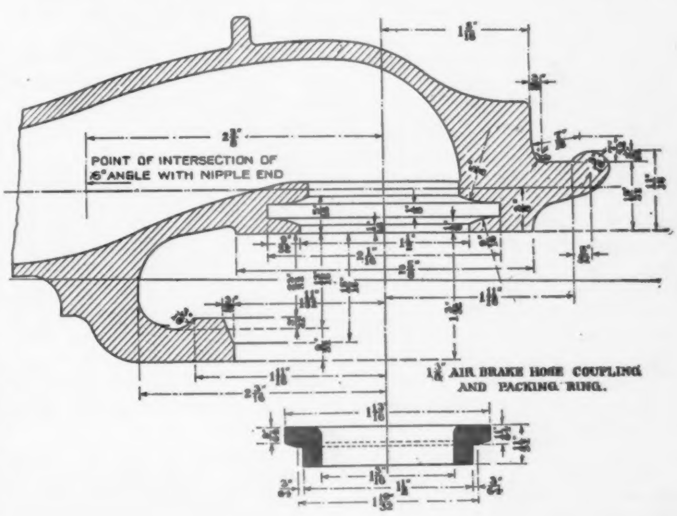
Action.—The report of the committee was received and the work ordered continued.

AIR-BRAKE HOSE.

Committee:—LeGrand Parish, chairman; J. Milliken, R. W. Burnett, J. R. Onderdonk, J. A. Carney.

The committee on air-brake hose strongly recommends that the railways make extensive experiments with devices designed to distribute the bending strain over nipple end of hose and afford protection from the damage by being struck with coupling when hose are uncoupled under pressure, without parting by hand. This latter condition of damage might be considerably reduced by some improvements in the design of hose coupling which would materially decrease the strains of uncoupling when parted under pressure other than by hand.

Upon request of the Executive Committee, we submit herewith recommendations for standard dimensions of air-brake hose couplings and gaskets. We also recommend the following change



in Rule 33, page 17: Omit "and hose applied without swelled end and not conforming to M. C. B. standard hose," making it read:

"Cars equipped with air-brake hose other than M. C. B. standard, on and after June 1, 1909, except 1¼-in. M. C. B. standard hose, and so branded, which hose has been manufactured previous to June 1, 1909.	Owners responsible.
"Except cars offered in interchange, where delivering company is responsible."	Delivering Company responsible.

The recommendation in regard to change in Rule 33 is made on account of the fact that under the present rule old M. C. B. standard 1¼-in. hose would not be permissible after June 1, 1909. This change is suggested to clear up a misunderstanding relative to this question.

This recommendation has been referred to the Arbitration Committee.

Action.—The recommendation as to the date at which the new rule should go into effect was adopted in connection with the report of the arbitration committee. The remainder of the report was referred to the committee on standards.

ELECTRICALLY LIGHTED PASSENGER EQUIPMENT.

The equipment of passenger cars with electric light, either by the straight storage or axle-lighting system, is being rapidly extended by a large number of railroads. In the interchange of these electrically lighted cars some trouble is experienced in charging the batteries or operation of the systems, by reason of lack of information concerning the make, type, charging rate, etc.

It has been suggested that the Master Car Builders' Association prepare a form of card to be pasted in the interior of all such electrically lighted cars to assist in the proper operation of the electric light equipment.

The Executive Committee believes the suggestion to be a good one, and, in order that it may be made operative at as early a date as possible, would recommend that the members of the Association owning or operating such cars at once take steps to place in each car so equipped a placard containing the following information:

A. B. C. R. R. CO.

System..................

Kind of equipment................................ Type.............
Kind of drive..
Ampere capacity ....
Voltage of system..
Kind of field regulation...
Location field regulation...
Voltage of regulator set at..

BATTERIES.

No. of cells of battery...........in series and...........sets in parallel.
Capacity of battery (8 hour rate)...............ampere hour.
Specific gravity of electrolyte at full charge..........................
Specific gravity of electrolyte for acid renewals.......................
Maximum charging rate in amperes.......................................
Maximum discharge rate in amperes......................................
Normal charging rate in amperes..
Size of overhead cables or main feed wires.............................
Kind of train connectors...
Where placed ....
Kind of charging terminals...
Position of positive pole..

BOX-CAR DOORS AND FIXTURES.

Committee—C. S. Morse, chairman; J. P. Young, G. N. Dow, J. A. McRae, C. F. Thiele.

At the 1908 convention this committee was continued to consider suggestions made during the discussion of the report offered at that time. The committee has revised its drawing for M. C. B. Sheet F to meet the criticisms offered.

Box-Car Doors and Fixtures.

The door-hanger bolt holes have been given definite location, and the door-hanger bolts have been increased from ⅜ inch to ½ inch in diameter. In place of the door guide plate there has been substituted a Z-bar, which stiffens the lower part of the door and renders unnecessary the use of the lower angle-iron stiffener recommended last year. By the use of this Z-bar a shorter door-guide bracket is obtained. The bolts securing the door handle have been increased from ⅜ inch to ½ inch, and lugs have been added, rendering the two screws unnecessary. The door hasp staple bolts have been increased in size from ⅜ inch to ½ inch, but the committee did not consider it advisable to increase the number of bolts.

Temporary Grain Doors.

Since the last convention the Executive Committee has requested the committee to consider also the subject of grain doors for box cars. Replies to the circular of inquiry indicate that the members are almost unanimously in favor of temporary grain doors. The committee has made a careful study of the various designs of temporary grain doors submitted and has prepared a drawing which would seem to be satisfactory from standpoints of price and efficiency. We would recommend specifications for grain doors as follows:

Temporary grain doors for box cars shall be made of two courses of lumber (long course, 6 ft. 10 in. long; short one, 4 ft. 11¼ in. long for a 6-ft. door opening), laid lengthwise, with two end strips 23 in. long and 6 in. wide, one strip at each end of the short course (the grain door is 24 in. high). Lumber of any suitable wood may be used. The lumber may have loose or unsound knots, except at the ends of the long course, but it must be free from rot or shakes that would prevent the nails from holding securely. The lumber in each door must be of uniform thickness and must be not more than 1 in. or less than 13/16 in. thick and may be of any width—3 in. or over—but each longitudinal joint shall be covered by a board that extends not less than 2 in. on each side of the joint. The short course must be nailed to the long course with four rows of clinch nails, and each end strip with twenty nails, all staggered and spaced as shown on the drawing, driven home and properly clinched; where the width of the lumber used makes them necessary, a greater number of nails must be used to secure a strong and workmanlike job. The door, when completed, must be grain tight, with no holes or cracks extending through it; also top and bottom edges of the door must be straight. Clinch nails must not be less than 2¼ in. in length.

In order to identify the ownership of temporary grain doors and to aid in their return, the doors should be stenciled with the owners' initials. The present cost of grain doors is a very considerable item, and a large saving would be made if the doors were returned to the owners.

Discussion.—This report was very thoroughly discussed. There was some question as to whether additional bottom door brackets should be provided for the box car side door.

The temporary grain door is a source of great expense; $90,000 a year is expended on this item by the Canadian Pacific and $200,000 by the C. B. & Q. Mr. Fowler (C. P. R.) thought that it would be necessary to give protection to the owner of the car or exclude it from owner's responsibility, or go to metal grain door. His road had been experimenting with a simple sheet metal door stiffened with angles or T irons, which is giving satisfactory results.

The 25,000 box cars on the C. B. & O. average only eight trips apiece per year with grain or other commodities requiring the use of grain doors. Part of the trouble is being overcome on the C. B. & O. by additional supervision at the elevators and along the line.

Mr. La Rue (C. R. I. & P.) stated that the General Managers' Association of Chicago was making an extended investigation of the problem of reclaiming grain doors which might effect a solution of this problem.

Action.—The report was accepted and the committee continued.

SUBJECTS.

Committee: H. D. Taylor, Chairman; A. W. Gibbs, J. S. Lentz.

The committee recommends that the subjects for committee work for the 1910 convention be limited to the following:

1. Steel hopper and drop-bottom gondola cars—clearance for third-rail construction, and design of the door itself to enable it to be kept tight when handling heavy commodities, such as ore, etc., and under the rough usage incident to the loading of billets, pig-iron, and other heavy commodities loaded from a considerable height.
2. Construction of car roofs, end bracing of box car superstructure, and bracing for side doors.
3. Maximum height of flange of wheels in service to prevent damage to track without danger to the wheels.
4. Springs for freight car trucks—revision of specifications, covering design, material, and requirements as to heat treatment.
5. Damage to cars by car-dumpers, and the remedy.

The committee in restricting the list of subjects, is not unmindful of the fact that before the convention other subjects of immediate importance may develop, and room is thus given for the inclusion of such subjects. It is also aware that some of the subjects for topical discussion at the 1909 convention may, as a result of such discussion, be desirable for committee action during the coming year, and it would reiterate the importance of limiting the number of subjects so as to secure better opportunity for discussion.

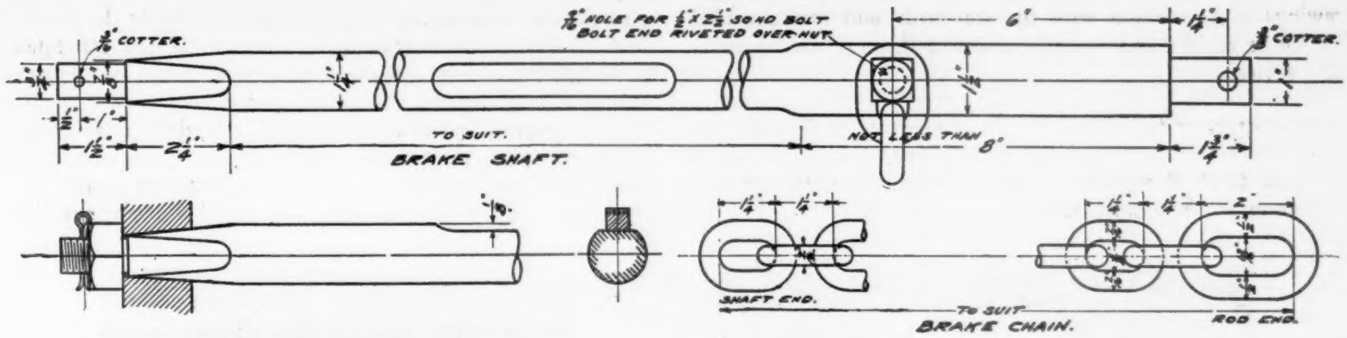
It is recommended that the following subjects be referred to the regular committees having such work in charge:

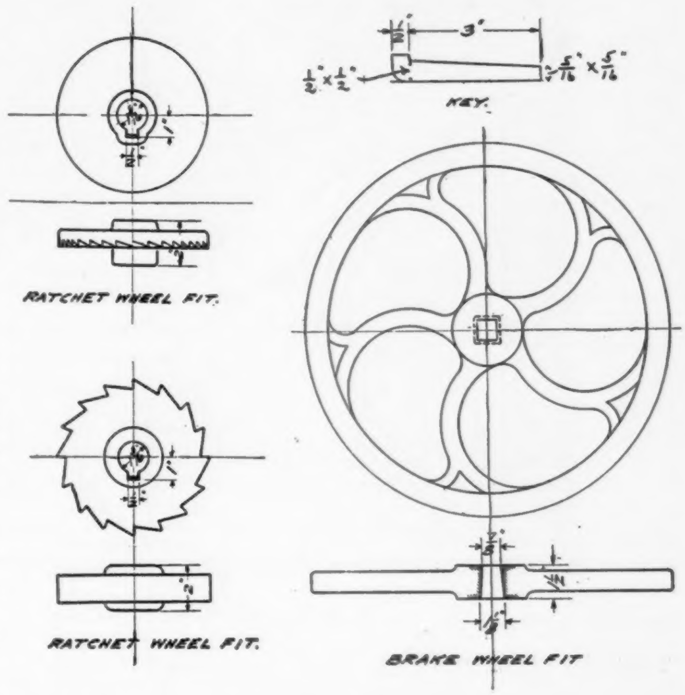
Breakage of bottom arch bars, to Committee on Freight Car Trucks.

Side-bearing clearance and location, to Committee on Side Bearings.

Leverage for hand brakes, to Committee on Train Brake and Signal Equipment.

Strengthening of air hose with some covering or otherwise so as to lessen the wrecks caused by burst hose, to Committee on Air-brake Hose, with definite instructions to investigate and report.





TRAIN BRAKE AND SIGNAL EQUIPMENT.

Committee:—A. J. Cota, chairman, F. H. Scheffer, R. K. Reading, E. W. Pratt, R. B. Kendig, T. L. Burton, E. Posson.

At a meeting of the Executive Committee held in Chicago on July 13, 1908, the name of the Committee on Air Brake Tests was changed to read, "Train Brake and Signal Equipment," and it was decided to increase the scope of the committee's work to take in the entire subject of air brake and signal equipment of cars for both automatic and foundation brakes.

Test Rack.—The new 100-car triple valve test rack for 10-inch freight equipment, which was authorized to be erected at Purdue University, Lafayette, Indiana, is now installed in a new building provided for that purpose.

Code of Triple Valve Tests for 100-Car Train.—One of the principal duties assigned to the committee is the formulation of a revision of the present code of tests for triple valves. This subject has been taken up with the various air-brake manufacturers, but we regret to report that on account of the inability of more than one manufacturer to furnish triple valves in time for such tests the committee is unable to submit a revised code for the 1909 convention, and asks that further time be given to consider this subject.

Standard Brake Shaft, Brake Wheel, etc.—(a) To design a standard brake shaft, brake wheel, brake-wheel fit, ratchet wheel and ratchet-wheel fit.

(b) A uniform method of fastening brake wheel and ratchet to staff, the brake shaft to be made of one piece.

(c) Location of the attachment of the brake chain to the winding barrel.

(e) Increase in size of brake chain and bolt fastening the chain to brake staff.

A circular of inquiry was addressed to the members asking for certain information concerning the present practice regarding brake shafts and their attachments; replies received to this circular covered over thirty-eight per cent. of the total number of cars represented in the Association. When these replies were received and tabulated there were found to be such marked differences in the dimensions that no definite decision as to the proper dimensions could be arrived at without arbitrarily taking dimensions which would represent the greatest number of cars interested. This is what your committee has done.

After determining the dimensions in this way, a separate plate has been prepared showing recommendations for the brake shaft, brake chain, manner of fastening brake chain to brake shaft, size of wheel fit for brake wheel, and a size and form of fit for the ratchet wheel and a key for securing the ratchet wheel to the brake shaft. The committee recognizes that these dimensions are more or less arbitrary, on account of the manner in which they were obtained, and would recommend their use only on new cars to be built hereafter, or in rebuilding old cars.

On account of the great difference and variety of ratchet wheels the committee is not at this time able to recommend any more than the shaft fit in the ratchet. The same can be said about the form and diameter of brake wheel; the committee did not deem it as being of sufficient importance to arbitrarily make a design for the acceptance of the Association.

Foundation Brake Gear.—To propose sizes for rods and other details of foundation brake gears to suit the different types of air brake equipment. This question was raised principally from the extensive use being made of the 10-inch brake cylinder. During the transition period the committee thought best not to work over the several details, but instead to add a note under "levers and connections," Sheet M. C. B. 9, stating that for brake cylinders larger than 8 inch or for brake cylinder pressures above 50 pounds per square inch, the size of brake rods and brake levers shown would be increased, if necessary, so that the fiber stress shall not exceed 15,000 pounds per square inch for rods and 23,000 pounds per square inch for levers.

A suggestion from the Committee on Standards was to consider the question of discontinuing the use of malleable iron material for bottom or truck lever connections. The committee, after carefully considering this question, recommends the erasure from Sheet M. C. B. 9 of all reference to malleable iron construction, leaving the alternate note in force, namely, that the truck connections be made of round iron or steel not less than 1⅝ inches in diameter.

Ball Joint Unions.—The question of ball joint unions and the interchangeability of parts. The committee is not prepared to report on this subject and asks for further time.

Action.—After considerable discussion it was decided to refer the report to letter ballot.

LOADING LONG MATERIAL.

The committee reported that it had no recommendations to make. Some matters had been presented to it, but they involved phases to which more time should be given before making definite recommendations.

ARBITRATION COMMITTEE.

A large number of changes in the interchange rules were suggested to this committee, a few of which were approved of by the committee. The recommendations of the committee were adopted; also some additional changes which were decided upon after the report was published. The decisions of the arbitration committee made during the year were also approved of.

REVISION OF STANDARDS AND RECOMMENDED PRACTICE.

COMMITTEE:—T. S. Lloyd, chairman; J. E. Buker, T. M. Ramsdell, W. E. Dunham, R. L. Kleine.

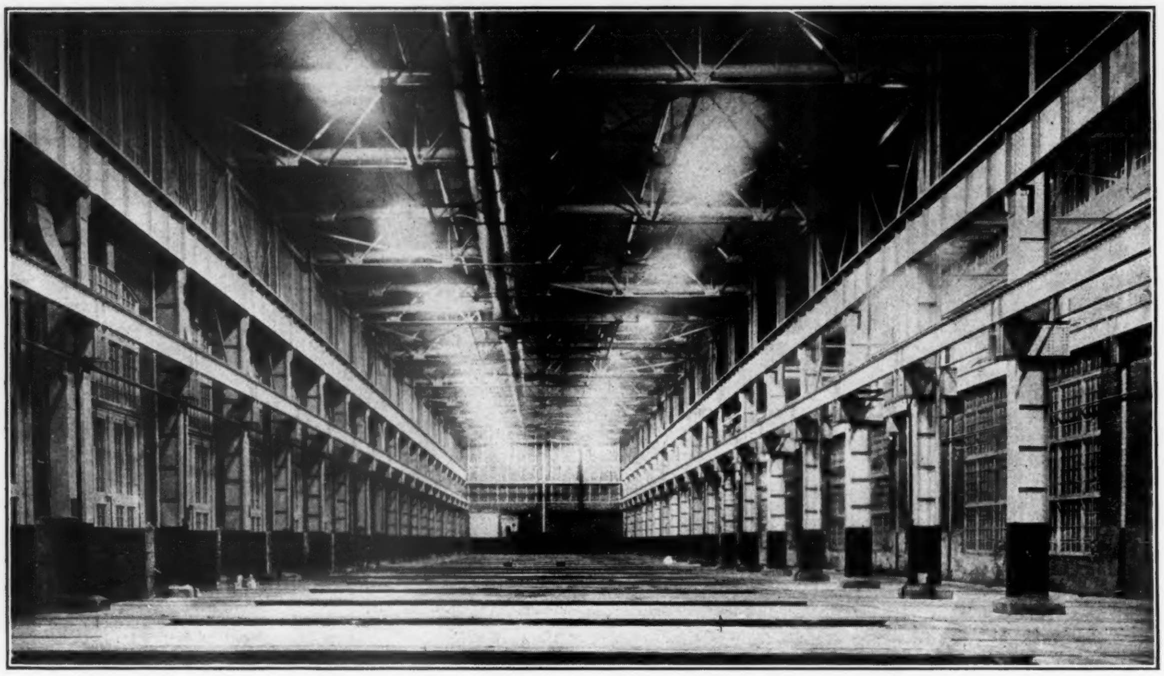
Action.—A number of suggestions were made to this committee in response to its circular of inquiry. Many of these were not approved by the committees; the others were approved or referred to other committees for investigation.

A minority report was presented by Mr. Kleine concerning the stenciling of cars and was adopted by the association. With

this exception the report of the committee was also adopted.

One of the most important recommendations was that the drawings in connection with the standards and recommended practice be revised and enlarged and that the text also be carefully revised.

[*An abstract of the reports of the committees on Coupler and Draft Equipment, Car Wheels, Freight Car Trucks and Revision of the M. C. B. Repair Card, together with discussions thereon, will appear in the August issue.*]



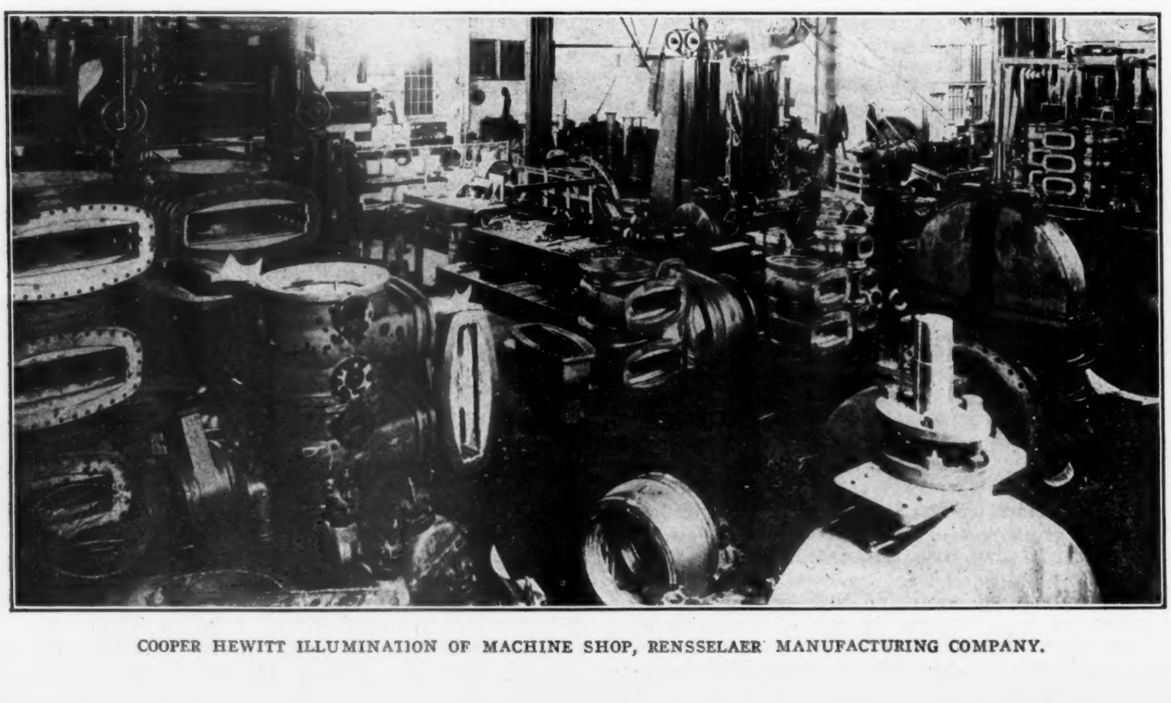
LOCOMOTIVE ERECTING SHOP ILLUMINATED BY COOPER HEWITT LAMPS.

THE LIGHTING OF ERECTING SHOPS AND HEAVY MACHINE SHOPS.

S. H. KNAPP.

The artificial lighting of the work in erecting shops and heavy machine shops, such that the employees can have working conditions equal to daylight, has in the past been a difficult problem. The great height of the heavy cranes has made it necessary to place most, if not all, of the lighting units underneath the cranes. In many instances it has been impossible to install lamps anywhere except on the side walls, although it is readily apparent that with an arc or incandescent cluster in that position much of the light is absorbed by the dark walls, and consequently the lighting is most unsatisfactory in the center of the room. Again, with low lighting from the side walls, locomotives or high machines may hide the source of light, producing large shadows in the center of the floor. Were it possible to obtain from skylights all the daylight required for satisfactory lighting, this arrangement would unquestionably give the best distribution and diffusion. Accordingly, if these satisfactory conditions can be artificially duplicated by placing the light source directly over the machines and workmen, a better distribution and the avoidance of eclipsing shadows will be obtained.

The Cooper Hewitt lamp, with its perfect diffusion resulting from a large luminous surface, makes possible the satisfactory illumination of a floor surface from a much greater height than was formerly considered possible. At the same time the comparative length of light source in the 50-inch tubes makes it possible for heavy cranes to pass underneath without causing any



COOPER HEWITT ILLUMINATION OF MACHINE SHOP, RENSSELAER MANUFACTURING COMPANY.

sharply defined shadows. This, with the absence of glare, as obtained from other illuminants, makes it possible for the mechanic to distinguish details in his work with accuracy.

The accompanying photograph shows an erecting shop of one of the large railroad systems lighted by 34 type F Cooper Hewitt lamps, giving 28,900 candle-power at a current consumption of 13.6 kilowatts. The building is 442 by 94 feet, or has 41,550 square feet of floor area. The height of the lamps from the floor is 50 feet, and 1,225 square feet of floor surface is allowed per lamp. In an adjoining erecting shop of three-fourths the size, two and one-half times as much power is being used to furnish arc lighting from the side walls, with most unsatisfactory results.

In heavy machine work, some idea of Cooper Hewitt illumination may be obtained from the accompanying view of a section in a room of the Rensselaer Manufacturing Company, at Troy, N. Y., where hydraulic valves to the weight of twenty-six tons are manufactured. This room contains 10,180 square feet of floor surface and is lighted by ten Type K Cooper Hewitt lamps, giving 7,000 candle-power. This installation has been in service since October, 1907, and the total cost for maintenance has been $24.00 to June 1st, 1909. It is interesting to compare this maintenance item for almost two years (in which the labor element is almost wholly eliminated), with that of any of the other systems of lighting, and to contrast it with the attention demanded by arc-lighting systems, particularly of the flaming type, which if used many hours per day total a maintenance cost almost prohibitive.

By using Copper Hewitt lamps the manufacturer can obtain a great volume of serviceable light at a minimum expenditure of electrical energy; the source of light may be installed at a great height and still give satisfactory floor illumination; the shadows can be almost wholly eliminated, and a perfect diffusion of pleasing light, the equal of daylight for manufacturing purposes, can be obtained. The very long life of the tubes—numerous installations having averaged over seven thousand hours' burinng—assures an economical maintenance, and the user is not subject to the annoyance and delay often caused where it is necessary to retrim arc lamps during working hours. Many of the large railroad systems throughout the country after testing different forms of illumination have installed and extended their systems of Cooper Hewitt lighting.

CORRECTION.

By accident in the press room, the denominator of the fraction within the parenthesis in Mr. Curtis' article on page 233 of the June number was lost. The formula should read:

$$C = G - \left(\frac{2HE}{G}\right)$$

NUT LOCKS.—The wonderful growth during recent years of the use of nut locks in locomotive and car construction may be indicated by the fact that 60,000,000 Bartley nut and bolt fasteners are now in use, although the manufacture of these was only commenced in July, 1902. In 1902 The American Nut & Bolt Fastener Company, of Pittsburgh, employed twelve men who made about 400 of these per day by hand. To-day a large factory is equipped with automatic machinery which has a capacity of 200,000 per day. Over 700 different kinds, shapes and sizes of Bartley fasteners are manufactured.

THE ABUSE OF BELTING.—It is a fact that in the average shop very few belts become unfit for use through legitimate wear, but rather through accidents or improper care. Where the care of the belts is left to the workman, the belts are usually far too loose, and when a belt slips it is less trouble for the workman to reduce his speed, feed, or depth of cut, or as a last resort to use rosin to make the belt pull. This use of rosin will ruin any belt in a very short time.—*Prof. C. H. Benjamin before the A. S. M. E.*

CANADIAN PACIFIC RAILWAY SAFETY LEAGUE.

The Canadian Pacific Safety League, of West Toronto (said to be the first of its kind in America), held a grand smoking concert on Friday evening, May 21st. About 300 employees were present. Thirteen meetings of the League have been held to date with much benefit to those who have attended. Upwards of thirty rules and other practical topics have been discussed, some of them several times, and as a result a number of rulings have been obtained. The league has 63 members enrolled, while upwards of two to three hundred employees have attended one or more meetings and come under its influence. A league has also been formed at Havelock, which is doing good work.

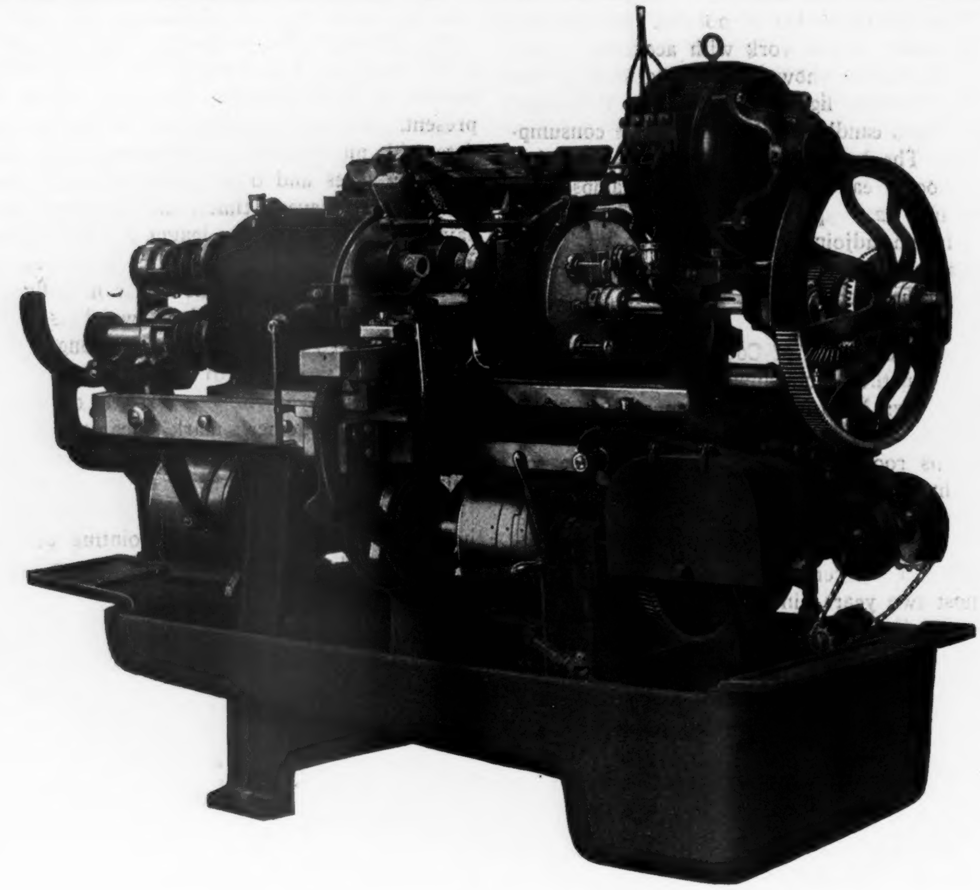
It is believed that every man belonging to the league and entering into the spirit of it, will become a more careful and competent employee; not one of the members has come under the stigma of a demerit mark since joining it. The aim of the league is to mutually benefit one another by lessons gained from daily experience on the road, in the shop, etc.; lessons which will teach the members to strictly observe the rules, to exercise the best possible judgment by pointing out the wrong way to do things and to observe caution in carrying out the high and important duties connected with the handling of trains, etc.

It may be added that the league was organized expressly for the employees, and while high officials are not excluded from the meetings they are not supposed to attend. The Safety League, therefore, is a place where employees may meet and express themselves freely on any matters affecting their work. All complaints discussed and suggestions made, etc., are strictly confidential and are acted on impersonally. C. Hudson, of the fuel department at West Toronto, is secretary.

STANDARDIZATION NEED NOT CHECK PROGRESS.—It must not be understood that the standards are so inflexibly maintained as to check improvement and initiative. Every officer and employee concerned knows that suggestions and criticisms are welcome, and as soon as proof can be offered that a new device or practice is better than the old its adoption quickly follows. Our plan requiring all officers concerned to vote on the adoption of a new device certainly curbs costly and ill-considered experiments. Nothing in our policy forbids experimenting with new devices, but it does forbid their adoption and use on a large scale until their merit has been thoroughly demonstrated to the satisfaction of all the general officers interested. Our officers appreciate that they are working out an experiment in railroad operation, and the knowledge that a new idea or successful device of any sort, if proven successful, will be adopted as standard practice on all of the Associated Lines acts as a powerful stimulus to originality and initiative.—*J. Kruttschnitt before the New York Railroad Club.*

RAILROAD EMPLOYEES AND THE PUBLIC.—It is unfortunately true that all railway employees are not uniformly courteous and considerate in their dealings with the public. The improvement of the service of this company in this respect is a matter to which I am giving a great deal of personal consideration. There are necessarily many cases of improper treatment of passengers and shippers that can never come to our attention, unless they are made the subject of complaint. I appreciate the fact that people are often deterred from making complaint by the fear that it might result in the discharge of the offending employee, but discharge in such a case would only be resorted to after all other methods had failed.—*W. W. Finley.*

INDIVIDUAL DRINKING CUPS.—The D., L. & W. Railroad has installed in the cars on some of its best passenger trains, an apparatus for delivering individual paper drinking cups to the passengers. The arrangement is such that each cup used must be either destroyed or carried away and each passenger takes a fresh cup which has been manufactured and put in the machine without being touched by the hands.



MULTIPLE SPINDLE AUTOMATIC SCREW MACHINE.

The standardization of parts and the concentration of manufacture on railroads has made possible the introduction of highly specialized labor-saving machinery in railroad shops. The automatic screw machine will turn out a much greater amount of work than the hand screw machine; it occupies about the same floor space and requires only ¼ to 1/6 the attention, one man being able to operate several of these machines. The automatic machine is not so complicated as might be expected and even a multiple spindle machine of this type can be attended to by practically the same class of labor as used on a hand screw machine. The saving in the labor cost, great as it is for the automatic over the hand machine, is still greater with the multiple spindle machine, since all the operations on a piece are performed at the same time.

The application of the individual motor drive to these machines has also done much to increase their productiveness and efficiency by preventing the breakage of tools, allowing the high speed of the machine to be used to a greater extent and by bringing the entire control of the machine under the hand of the operator, while in a position to observe the work.

Some idea of the work which may be done by the multiple spindle automatic screw machine (an "Acme" No. 56, 2¼ in. chuck capacity, 10½ in. feed and 8 in. mill) may be gained from the following data.

The hexagon cap screw, shown in Fig. 1, is made from 1⅝ in. hexagon black steel at the Montreal shops of the Canadian Pacific Railway. They are produced at the rate of sixteen per hour.

The drilled piece without threads, Fig. 2, is made from 1 15/16 in. cold rolled steel by the Chicago & Northwestern Railway at the rate of eight pieces per hour. The larger hole is 1⅜ in. in diameter and 3½ in. long, making a heavy drilling cut.

The small wrist pin, Fig. 3, was made by the H. K. Porter Company, Pittsburgh, Pa., at the rate of 9½ pieces per hour.

The staybolt sleeve at the left in Fig. 4 is made from 1⅞ in. cold rolled steel at the Juanita shops of the Pennsylvania Railroad at the rate of 32½ pieces per hour. Both threads are cut at one time in the third position; the smaller one is a pipe thread and the larger one a machine thread. The sleeve at the right is made from 1⅞ in. cold rolled steel at the rate of 37½ pieces per hour.

The "Acme" multiple spindle automatic screw machine has four spindles, each of which carries a rod or bar of metal. Eight

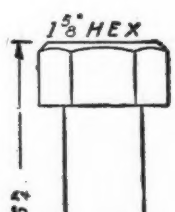


FIG. 1.

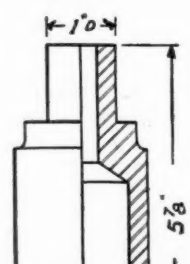


FIG. 2.

tool positions—four from the side and four from the end—allow an exceptional number of operations. More than this are frequently possible by a combination of tools in one or more positions, or by the use of special attachments.

All the operations are performed simultaneously, consequently the time for finishing any one piece is that required to perform the longest single operation on it. The method is a progressive one, a finished piece being cut from each bar after it has been successively operated on in the four positions.

Accuracy of alignment is maintained by a positive locking of

the spindle carrying cylinder, compensation for wear being provided. All rotary movements are continually in one direction, thus eliminating the strains due to reversing the revolving parts. The threading operation is accomplished while the stock is stationary, the tool being rotated at the speed best suited to the

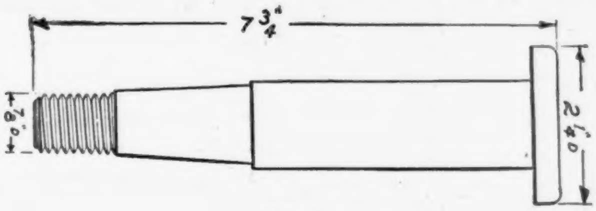


FIG. 3.

size of the piece, the pitch of the thread, and the cutting qualities of the stock. No force, other than the rotary, is required, the lead of the tools being governed entirely by the pitch of the thread. A positive start for the thread is provided by a lever movement. All the tools are flooded with oil while in operation.

The absence of multiple belts simplifies the application of power to the machine, and makes the relation between the revolutions of the stock and the lead of the tools constant and positive, making possible accurate timing of changes from so-called idle movements (withdrawal of tools, indexing cylinder, etc.)

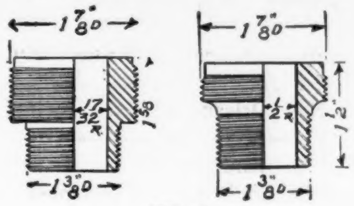


FIG. 4.

to the cutting movements. The maximum use of the high speed is made possible, resulting in a larger production; the cost of maintenance and repairs is reduced; operation is simplified and made more convenient.

An individual motor drive may be applied by the substitution of a driving gear in place of the driving pulley and the addition of a motor platform and support, with the motor and the controller. Either direct or alternating current motors may be used. No additional floor space is required and the motor driven machines are symmetrical and compact in appearance. These machines are manufactured by The National-Acme Manufacturing Company, Cleveland, Ohio.

DINNER TO HUGH M. WILSON.—As a mark of appreciation of his work and of regard for his personality, about 200 friends of Hugh M. Wilson, formerly publisher of the *Railway Age*, gathered at a banquet at the Hotel Chelsea, Atlantic City, on the evening of June 19 and paid to him one of the most remarkable tributes ever given to a man in this field of work. The sincerity of the speakers in their almost extravagant praise, and they included some of the most prominent men in the railway and railway supply worlds, as well as of the applause of the listeners, was unmistakable. His ability, resourcefulness, energy, patience, cheerfulness and loyalty were recounted with ready eloquence, and every eulogistic remark was greeted with enthusiastic plaudits.

Representatives from railroads in all parts of the country, some of the largest manufacturing firms and all of the railroad press were present to greet their common friend.

This fully deserved tribute was arranged under the direction of the following general committee:

F. A. Delano, Daniel Willard, W. F. Allen, A. W. Gibbs, F. H. Clark, J. F. Deems, Wm. McIntosh, C. A. Schroyer, C. A. Seley, F. A. Barbey, G. M. Basford, Scott H. Blewett, J. Alexander Brown, George H. Bryant, S. P. Bush, O. H. Cutler, Frank Dinsmore, Harry W. Frost, B. A. Hegeman, Jr., J. M. Hopkins, George A. Post, Charles Riddell, W. M. Simpson and Albert Waycott.

ASBESTOS PROTECTED METAL.

For roofing, headlining or sheathing of passenger cars, for use in box car roofs or for the roofing or siding of buildings Asbestos Protected Metal is in many respects an ideal material. It consists of a sheet of steel dipped in a special asphalt compound. The steel is thus hermetically sealed within the compound so that air, moisture, gases or acids cannot attack it. Pure asbestos felt is then rolled into the compound on both sides of the sheet.

While the sheet is very light in weight it is thoroughly protected from rust and corrosion. It thus has an important advantage over iron and sheet steel, which must be frequently repainted to keep them in a serviceable condition. Another important advantage is that it is not subject to condensation on the inner surface when used in building construction. The material is fireproof and will stand a very great amount of heat without drawing or buckling. Where beaded or corrugated sheets are used in building construction, wood sheathing may be eliminated, greatly reducing the fire risks. It offers special advantages for use as headlining of passenger coaches as it may be easily bent or shaped to suit the contour of the roof without danger of cracking or breaking. The asbestos surface is treated with a special process so that it will take any desired finish in solid colors, tints or imitation of grained woods.

This material is made in two qualities, one with a grade of asbestos suited for interior finish and the other on which a special hard waterproof felt is used suited for general roofing and siding purposes in building construction. It is manufactured in several forms and in three colors—white, gray and terra cotta—by the Asbestos Protected Metal Company, Canton, Mass.

HYDRAULIC JACKS.

It is difficult to handle a hydraulic jack from place to place, especially if it weighs more than a hundred pounds, whether it is carried by hand or is loaded on a truck after each using. To overcome this the Watson-Stillman Company has designed a line of jacks having wheels on the base, as shown by one of the illustrations. By tilting the jack so as to throw the weight on the wheels it can readily be moved about from place to place

NEW HYDRAULIC JACK.

by means of the handle. These jacks are made in eleven sizes of from 20 to 50 tons capacity and lifts of from 12 to 18 inches. The wheels touch the floor only when the jack is tilted and are not in the way during the lifting operation. If it is desired to use the jack at an angle, it can be tilted in the opposite direction to the wheels; when it is laid flat upon the side, the ram will push out to its entire lifting length.

The head is enlarged sufficiently so that the jack will not stop working for lack of filling, even if there has been a slight leakage. An independent steel claw (not shown in the illustration)

can be used, when desired, for lifting from near the ground. This is more convenient than a permanently attached claw, as the independent part is easily applied when a low lift is required, and its removal at other times allows the jack to be made of considerably lighter weight. The weight is comparatively small because the whole jack is made from steel, and the parts under greatest strain, such as the ram and cylinder, are machined from a solid bar of higher carbon steel than is usually found in hydraulic or other jacks. This jack, though plain in construction, has proved very reliable in service, and on account of its special design greatly facilitates the handling of heavy equipment.

It is sometimes inconvenient to work the lever of a jack of the internal pump type because of the lack of room, or insufficient footing. There are also places where only a short space is available to place the jack—another condition which cannot be met successfully with the ordinary internal pump jack. In some instances it is advisable for the operator for his safety to be some distance from the jack. To meet these conditions the Watson-Stillman Company has put on the market an independent pump hydraulic jack shown in the second illustration and which is furnished in fifty-three sizes of from 2 to 1,200 tons capacity. The various sizes of the jack proper have maximum ram movements of from 4 to 8 inches. The pump is connected to the jack by means of flexible copper tubing, which may be of any length suitable to the work in question. The jack may be operated up to a pressure of 450 pounds per square inch on the ram by means of the extension lever. The gauge may read in pounds per square inch, or in tons load upon the jack, or both. When equipped with the gauge the jack may be used between two fixed platens for making compression tests, testing the tightness of forced fits, etc.

INDEPENDENT PUMP HYDRAULIC JACK.

A Good Convention Issue.—*The Railway & Engineering Review* is to be congratulated on the issue of June 19th. It is a difficult task to get hold of good material in the line of new car designs just at this time and the editors rather surprised their friends by bringing out in detail a new design of fifty-ton steel gondola car as well as the details of an all-steel sleeping car which is being built for the Pennsylvania Railroad by the Pullman Company.

PERSONALS.

B. R. Moore has been appointed master mechanic of the Mississippi Central Ry.

William M. Saxton has been appointed the master mechanic of the North Coast Railroad, with office at Spokane, Wash.

R. Preston has been appointed master mechanic of the Central division of the Canadian Pacific Ry., with office at Winnipeg.

Henry Montgomery has been appointed master mechanic of the Allegheny division of the Pennsylvania R. R., with office at Oil City, Pa.

J. A. Baker has been appointed master mechanic of the Vera Cruz & Ithmus Ry., with headquarters at Tierra Blanca, Vera Cruz, Mex.

W. E. Fowler, master car builder of the Canadian Pacific Ry. and a past president of the Master Car Builders' Association, has resigned on account of ill health.

R. W. Burnett, assistant master car builder, Eastern Lines, Canadian Pacific Ry., has been appointed master car builder, succeeding W. E. Fowler, resigned.

The jurisdiction of T. O. Sechrist, master mechanic, with office at Ferguson shops, Ferguson, Ky., has been extended over the entire Cincinnati, New Orleans & Texas Pacific Ry.

B. D. Lockwood, mechanical engineer of the Cleveland, Cincinnati, Chicago & St. Louis Ry., has resigned. Mr. Lockwood has been appointed assistant chief engineer of the Pressed Steel Car Co.

H. R. Brigham has been appointed road foreman of engines of the Buffalo division of the Pennsylvania R. R., with office at Buffalo, N. Y., succeeding G. O. Taylerson, assigned to other duties.

W. G. Seibert has been appointed master mechanic of the Missouri Pacific and the St. Louis, Iron Mountain & Southern Rys., with office at Fort Scott, Kan., succeeding T. F. Carbery, assigned to other duties.

M. E. Hamilton has been appointed the general air-brake inspector of the Atchison, Topeka & Santa Fe System, with office at Topeka, Kan. He will have full charge of all matters pertaining to air-brakes.

T. F. Carbery, master mechanic of the Missouri Pacific and the St. Louis, Iron Mountain & Southern Rys., at Fort Scott, Kan., has been appointed general foreman of the shops of these roads, with office at St. Louis, Mo.

A. H. Powell has been appointed master mechanic of Salt Lake and Humboldt division of the Western Pacific Ry., in charge of the motive power and car department, with headquarters at Salt Lake City, Utah.

R. G. Turnbull has been appointed master mechanic of the Missouri Pacific Ry., the St. Louis, Iron Mountain & Southern and leased, operated and independent lines, with office at Osawatomie, Kan., succeeding M. M. Myers, resigned.

G. W. Robb, assistant master mechanic Grand Trunk Pacific Ry. at Rivers, Man., has been appointed master mechanic, in charge of motive power, cars and shops, with office at Rivers, succeeding Wm. Gell, resigned on account of ill health.

J. H. Murphy, master mechanic of the Cincinnati, New Orleans and Texas Pacific Ry., at Ludlow, Ky., has been appointed general foreman at the Ludlow shops, with jurisdiction over the mechanical department forces from Cincinnati to Lexington, inclusive, and his former office has been abolished.

C. E. Chambers has been appointed general master mechanic of the Central Railroad of New Jersey and will have charge of the assignment of motive power over the entire system and will perform such other duties as may be assigned to him. The office of division master mechanic at Ashley has been abolished.

T. R. BROWN.—For the purpose of enlarging their New York interests and developing the engineering end in connection with large steam power station installations, E. Keeler Company, of Williamsport, Pa., have associated with them T. R. Brown as chief engineer, with headquarters at 29 Broadway, New York.

Mr. Brown is an engineer of wide practical and theoretical experience. He was formerly connected with the Pennsylvania Railroad as master mechanic of the Juniata shops at Altoona; also with the Westinghouse interests and lately with the American Car & Foundry Company. He is particularly well equipped for the new work he has taken up.

BOOKS.

Westinghouse E-T Air Brake Instruction Pocket Book. By Wm. W. Wood. Cloth. 5 x 7 in. 236 pages. Fully illustrated. with colored plates. Published by Norman W. Henley Publishing Co., 132 Nassau street, New York. Price, $2.00.

The new Westinghouse engine and tender brake equipment is most completely described in detail in this book, which is written by an air brake inspector. It is profusely illustrated with colored plates, enabling the reader, to trace the flow of pressures throughout the entire equipment. It is written in such form to be equally as good for a beginner or for an advanced engineer. It contains questions and answers on this equipment, telling what the brake is; how it should be operated and what to do when it is defective. It is claimed by the publisher that not a question can be asked of a man up for promotion on either the No. 5 or No. 6 E-T equipment that is not answered in this book. The arrangement is logical, the descriptive matter clear and the illustrations exceptionally good.

CATALOGS.

INTERURBAN RAILWAY EQUIPMENT.—Bulletin No. 1053 from Allis-Chalmers Co., Milwaukee, Wis., includes very complete illustrated descriptions of the equipment of several of the best interurban electric railways of the country.

ENGINE ROOM GAUGE BOARDS.—The American Steam Gauge & Valve Mfg. Co., 208 Camden street, Boston, Mass., is issuing a small catalog illustrating many different arrangements of slate and marble engine room gauge boards.

INDUCTION MOTORS.—The Triumph Electric Co., Cincinnati, O., is issuing Bulletin No. 351 devoted to the subject of induction motors in all sizes. The construction of the details is fully covered and illustrations are shown of direct connected sets for various purposes.

GRINDING AND POLISHING MACHINERY.—The Webster & Perks Tool Co., Springfield, O., is issuing a catalog given up to illustrations and full specifications of grinding and polishing machinery, which is shown in many different sizes and types. The prices are included.

ELECTRIC HEADLIGHT.—The Dake-American Steam Turbine Co., Grand Rapids, Mich., is issuing a leaflet fully illustrating and describing the Dake Electric headlight, which is claimed to consume less than one-sixth the amount of steam required by any other headlight set on the market, candle power considered.

PIPE CUTTING MACHINERY.—The Curtis & Curtis Co., Bridgeport, Conn., is issuing a 36-page catalog devoted entirely to apparatus for pipe cutting and threading. The Forbes patent die stock used with both hand and power is fully illustrated and described in practically any desired size or arrangement. Various accessories demanded in work of this kind are also shown.

ELECTRICAL APPARATUS.—Among the recent bulletins being issued by the General Electric Co., Schenectady, N. Y., is No. 4669, illustrating and describing the various types of Curtis steam turbine for low and mixed pressures. No. 4662 illustrates and describes the various types of Thompson recording wattmeters for both direct and alternating current.

MOTOR CARS AND VELOCIPEDES.—The Buda Foundry & Mfg. Co., Railway Exchange, Chicago, is issuing catalog No. 134 devoted to illustrations and brief descriptions of motor velocipedes, inspection cars, section gang cars, bridge gang cars and power cars. All of these cars are driven by gasolene engines and have proven to be most satisfactory in hard service. The Buda pressed steel wheels are used on all cars.

LUBRICATORS.—The Detroit Lubricator Co., Detroit, Mich., is issuing a new 61-page catalog which fully illustrates and describes oiling devices of all kinds, as well as special gate and globe valves and other pipe fittings. In addition to sight feed lubricators for stationary and locomotive work in many sizes, there are oil cups, oil pumps, grease cups, special oiling devices for large engines, water glasses, etc. Numbered sketches are included giving the names and prices of various repair parts for different sight feed lubricators. A telegraph code is provided.

LUBRICATION VERSUS FRICTION.—The Dearborn Drug and Chemical Co., Postal Telegraph Bldg., Chicago, is issuing a very interesting booklet under the above title. It is devoted to an extended and semi-technical discussion of the value of different lubricants and the proper lubricants to be used under any set conditions. The manufacture and blending of various kinds to best meet the demand is fully considered and the methods of testing lubricants for all the various qualities are fully described. This booklet will be found to be most interesting to all machinery users.

GASOLENE LOCOMOTIVES.—The Milwaukee Mfg. Co., Milwaukee, Wis., is issuing a 28-page catalog illustrating and describing several different models of gasolene locomotives, which include sizes suitable for light shifting around manufacturing plants up to large sizes capable of handling a number of passenger or freight cars for some distance. These locomotives require but one operator and tables are included in the catalog giving the specifications and the hauling capacity on various grades at various speeds. The locomotives are said to be particularly well adapted for motor car service.

HYDRAULIC MACHINERY.—William H. Wood, Engineer, Media, Pa., is issuing a book of particulars of his improved hydraulic machinery. It contains 56 pages, giving half-tone and line drawing illustrations, with brief descriptions, of a great variety of riveters, flangers, presses, etc. There are also included hydraulic wheel presses, and flanging clamps specially adapted for railway shops use. Hydraulic pumps and various accessories for machinery of this kind are also shown. Many testimonial letters are reprinted in the back of the catalog, which speak most highly of the machinery manufactured by this company, now in operation.

VERTICAL TURRET LATHE.—The Bullard Machine Tool Co., Bridgeport, Conn., is issuing a very attractive catalog, fully illustrating and describing what is called "the vertical turret lathe" which actually performs most of the functions of a high class turret lathe, the centers being in a vertical instead of a horizontal position. This is a machine tool of exceedingly high character of design and construction and the illustrations in the catalogue are so arranged as to make clear its many valuable features. Operating instructions are fully given and sketches showing the surprising adaptability of the machine to work on special shapes, several tools being in operation at one time, are very convincing. The catalog is arranged and printed in excellent taste throughout.

NOTES.

LIMA LOCOMOTIVE & MACHINE CO.—George L. Wall, who has been mechanical engineer of this company, has been promoted to assistant general manager.

H. W. JOHNS-MANVILLE CO.—Henry J. Bellman has been appointed manager of the hair felt department of this company with office at 100 William street, New York.

NORTH-WESTERN METAL MANUFACTURING CO.—A. Munch, formerly sales-manager of the Northern Metallic Packing Co., of St. Paul, Minn., has become identified with the above company, of Minneapolis, Minn., as sales-manager of the Railway Department.

QUINCY-MANCHESTER-SARGENT CO.—In order to simplify details in connection with correspondence, telephoning, etc., the Quincy-Manchester-Sargent Co., Plainfield, N. J., has deemed it advisable to change its name and hereafter will operate under the corporate name of "The Q M S Co."

SAFETY CAR HEATING & LIGHTING CO.—The axle-driven dynamo system of electric car lighting is reported as coming into favor very rapidly as business improves. Among the recent orders for equipping cars with this system are the following: Rock Island, 157 cars; Southern, 125 cars; New York Central, 25 cars; Lehigh Valley, 15 cars, and Pullman Co., 10 cars.

WOLFE BRUSH CO.—I. R. L. Wiles, until recently Supply Agent of the Missouri Pacific Ry., has resigned his position to become Second Vice-President of the above company with office at Pittsburgh, and will have charge of the railroad department. This company has made railroad brushes almost exclusively since 1851.

LINCOLN MOTOR WORKS COMPANY.—This company announces that it has changed its name to the Reliance Electric & Engineering Co., the management, however, remaining the same. This company is now specializing in machine shop practice and is equipped to design and manufacture all mechanical details and driving mechanism necessary in applying motor drives to any class of machinery.

SAFETY CAR HEATING & LIGHTING CO.—This company calls attention to the fact that the wreck on the Union Pacific Ry. at Castle Rock, Utah, on March 1, which caught fire, due, it was believed at first, to the rupturing of a Pintsch gas tank, has now been more fully investigated. It has been definitely established that the baggage car on which the fire occurred was lighted by oil lamps and not by Pintsch gas. None of the other cars, which were equipped with Pintsch gas, had their tanks ruptured.

BALDWIN LOCOMOTIVE WORKS.—Application has been granted by the Governor of Pennsylvania for the incorporation of the Baldwin Locomotive Works of Philadelphia to take over the business now conducted under the name of Burnham, Williams & Co. This business was founded in 1831 by Matthias W. Baldwin. The capital of $20,000,000, which the firm has heretofore had invested in the business, will be the capital stock of the company, and no stocks or bonds will be placed on the market. The present partners will be the officers and board of directors of the new corporation. In addition to the Baldwin Locomotive Works of Philadelphia, the company also owns the Standard Steel Works and a large branch plant at Eddystone, Pa. The transfer to the new company will occur July 1.

CONVENTION EXHIBITS.

The exhibits at the Master Mechanics' and Master Car Builders' conventions at Atlantic City were even more extensive than last year, which was a record breaker. It is also understood that a number of firms who applied too late found it impossible to secure accommodations. Among the exhibitors were the following:

Adams & Westlake Company, Chicago, Ill.
Ajax Manufacturing Company, Cleveland, Ohio.
American Balance Valve Company, Jersey Shore, Pa.
American Blower Company, Detroit, Mich.
American Brake Company, St. Louis, Mo.
American Brake Shoe & Foundry Company, Mahwah, N. J.
American Car & Foundry Company, New York, St. Louis and Chicago.
American Locomotive Company, New York, N. Y.
American Mason Safety Tread Company, Boston, Mass.
American Nut & Bolt Fastener Company, Pittsburgh, Pa.
American Specialty Company, Chicago, Ill.
American Steel Foundries, Chicago, Ill.
American Tool Works Company, Cincinnati, Ohio.
American Vanadium Company, Pittsburgh, Pa.
Armstrong Brothers Tool Company, Chicago, Ill.
Asbestos Protected Metal Company, Canton, Mass.
Ashton Valve Company, Boston, Mass.
Atha Steel Casting Company, Newark, N. J.
Barnett Equipment Company of America, New York, N. Y.
Besly & Company, Charles H., Chicago, Ill.
Bettendorf Axle Company, Davenport, Iowa.
Boker & Company, Herrmann, New York, N. Y.
Booth Company, L. M., New York, N. Y.
Bordo Company, L. J., Philadelphia, Pa.
Bowser & Company, Inc., S. F., Fort Wayne, Ind.
Brighton Brass & Bronze Company, Pittsburgh, Pa.
Brown & Sharpe Manufacturing Company, Providence, R. I.
Buckeye Steel Castings Company, Columbus, Ohio.
Buffalo Brake-Beam Company, New York, N. Y.
Bullard Machine Tool Company, Bridgeport, Conn.
Carborundum Company, Niagara Falls, N. Y.
Cardwell Manufacturing Company, Chicago, Ill.
Carnegie Steel Company, Pittsburgh, Pa.
Carter Iron Company, Pittsburgh, Pa
Celfor Tool Company, Chicago, Ill.
Chase & Company, L. C., Boston, Mass.
Chicago Car Heating Company, Chicago, Ill.
Chicago Pneumatic Tool Company, Chicago, Ill.
Chicago Railway Equipment Company, Chicago, Ill.
Chisholm & Moore Manufacturing Company, Cleveland, Ohio.
Chrome Steel Works, Chrome, N. J.
Cincinnati Bickford Tool Company, Cincinnati, Ohio.
Cincinnati Planer Company, Cincinnati, Ohio.
Cleveland Twist Drill Company, Cleveland, Ohio.
Clow & Sons, James B., Chicago, Ill.
Coale Muffler & Safety Valve Company, Baltimore, Md.
Coe Brass Manufacturing Company, Ansonia, Conn.
Commercial Acetylene Company, New York City, N. Y.
Commonwealth Steel Company, St. Louis, Mo.
Consolidated Car-Heating Company, Albany, N. Y.
Consolidated Railway Electric Lighting & Equipment Company, New York, N. Y.
Cooper-Hewitt Electric Company, New York, N. Y.
Crane Company, Chicago, Ill.
Crosby Steam Gage & Valve Company, Boston, Mass.
Curtain Supply Company, Chicago, Ill.
Dake-American Steam Turbine Company, Grand Rapids, Mich.
Damascus Brake-Beam Company, Cleveland, Ohio.
Davis-Bournonville Company, New York, N. Y.
Davis Expansion Boring Tool Company, St. Louis, Mo.
Davis Solid Truss Brake Beam Company, Wilmington, Del.
Dayton Malleable Iron Company, Dayton, Ohio.
Dearborn Drug & Chemical Works, Chicago, Ill.
Detroit Lubricator Company, Detroit, Mich.
Diamond Rubber Company, Akron, Ohio.
Dickinson, Paul, Incorporated, Chicago, Ill.
Dixon Crucible Company, Joseph, Jersey City, N. J.
Dudgeon, Richard, New York, N. Y.
Duff Manufacturing Company, Pittsburgh, Pa.
Duntley Manufacturing Company, Chicago, Ill.
Edwards Company, O. M., Syracuse, N. Y.
Electric Hose & Rubber Company, Wilmington, Del.
Electric Storage Battery Company, Philadelphia, Pa.
Fairbanks, Morse & Company, Chicago, Ill.
Farlow Draft Gear Company, Baltimore, Md.
Fisher & Norris ("Eagle" Anvil Works), Trenton, N. J.
Flannery Bolt Company, Pittsburgh, Pa.
Forsyth Brothers Company, Chicago, Ill.
Foster, Walter H., New York, N. Y.
Franklin Manufacturing Company, Franklin, Pa.
Franklin Railway Supply Company, New York, N. Y.
Frost Railway Supply Company, Detroit, Mich.
Galena-Signal Oil Company, Franklin, Pa.
Garlock Packing Company, Palmyra, N. Y.
General Electric Company, Schenectady, N. Y.
General Railway Supply Company, Chicago, Ill.
Gold Car Heating & Lighting Company, New York, N. Y.
Gould Coupler Company, New York, N. Y.
Grip Nut Company, Chicago, Ill.
Hammett, H. G., Troy, N. Y.
Hanlon Locomotive Sander Company, Winchester, Mass.
Harrington, Edwin, Son & Company, Inc., Philadelphia, Pa.
Home Rubber Company, Trenton, N. J.
Hunt-Spiller Manufacturing Corporation, South Boston, Mass.
Hutchins Car Roofing Company, Detroit, Mich.
Illinois Malleable Iron Company, Chicago, Ill.
Jenkins Brothers, New York, N. Y.
Johns-Manville Company, H. W., New York, N. Y.
Joliet Railway Supply Company, Joliet, Ill.
Joyce, Cridland Company, Dayton, Ohio.
Keller Manufacturing Company, Philadelphia, Pa.
Kelly-Arnold Manufacturing Company, Wilkes-Barre, Pa.
Lackawanna Steel Company, New York, N. Y.
Landis Machine Company, Waynesboro, Pa.
Landis Tool Company, Waynesboro, Pa.
Link-Belt Company, Philadelphia, Pa.
Lodge & Shipley Machine Tool Company, Cincinnati, Ohio.
Love Brake Shoe Company, Chicago, Ill.
Lupton's Sons Company, David, Philadelphia, Pa.
McConway & Torley Company, Pittsburgh, Pa.
McCord Company, Chicago, Ill.
McIlvain & Company, J. Gibson, Philadelphia, Pa.
Manning, Maxwell & Moore, New York, N. Y.
Mason Regulator Company, Boston, Mass.
Mogul Paint Company, New York, N. Y.
Monarch Steel Castings Company, Detroit, Mich.
Moran Flexible Steam Joint Company, Louisville, Ky.
Nathan Manufacturing Company, New York, N. Y.
National-Acme Manufacturing Company, Cleveland, Ohio.
National Boiler Washing Company, Chicago, Ill.
National Lock Washer Company, Newark, N. J.
National Malleable Casting Company, Cleveland, Ohio.
National Railway Service Co., Chicago, Ill.
National Tube Company, Pittsburgh, Pa.
Newhall Engineering Company, George M., Philadelphia, Pa.
Newton Machine Tool Works, Inc., Philadelphia, Pa.
New York Air Brake Company, New York, N. Y.
Niles-Bement-Pond Company, New York.
Norton Company, Worcester, Mass.
Norton Grinding Company, Worcester, Mass.
Parkesburg Iron Company, Parkesburg, Pa.
Pilliod Company, Swanton, Ohio.
Pittsburgh Equipment Company, Pittsburgh, Pa.
Pratt & Whitney Company, New York, N. Y.
Pressed Steel Car Company, Pittsburgh, Pa.
Queen City Machine Company, Cincinnati, Ohio.
Railway Business Association, New York, N. Y.
Railway Materials Company, Chicago, Ill.
Ritter Folding Door Company, The, Cincinnati, Ohio.
Robinson Company, Boston, Mass.
Royersford Foundry & Machine Company, Inc., Royersford, Pa.
Rubberset Brush Company, Newark, N. J.
Russell, Burdsall & Ward Bolt & Nut Company, Port Chester, N. Y.
Ryerson & Son, Joseph T., Chicago, Ill.
Safety Car Heating & Lighting Company, New York, N. Y.
St. Clair Air-Brake Company, Indianapolis, Ind.
Scullin-Gallagher Iron & Steel Company, St. Louis, Mo.
Scully Steel & Iron Company, Chicago, Ill.
Sellers & Company, Wm., Incorporated, Philadelphia, Pa.
Spencer Turbine Cleaner Company, Hartford, Conn.
Standard Coupler Company, New York, N. Y.
Standard Steel Car Company, New York, N. Y.
Standard Steel Works Company, Philadelphia, Pa.
Standard Tool Co., The, Cleveland, Ohio.
Sterling Steel Foundry Company, Pittsburgh, Pa.
Stoever Foundry & Mfg. Co., New York, N. Y.
Storrs Mica Company, Owego, N. Y.
Symington Company, T. H., Baltimore, Md.
Taylor Manufacturing Company, James L., Bloomfield, N. J.
Tindel-Morris Company, Eddystone, Pa.
Topping Brothers, New York, N. Y.
Underwood & Co., H. B., Philadelphia, Pa.
Union Draft Gear Company, Chicago, Ill.
Union Fibre Company, Winona, Minn.
Union Spring & Manufacturing Company, Pittsburgh, Pa.
U. S. Metal & Manufacturing Company, New York, N. Y.
Ward Equipment Company, New York, N. Y.
Watson Insulated Wire Company, New York, N. Y.
Watson Stillman Company, New York, N. Y.
Waugh Draft Gear Company, Chicago, Ill.
Welsbach Company, Gloucester, N. J.
West Disinfecting Co., Inc., New York, N. Y.
Western Railway Equipment Company, St. Louis, Mo.
Western Steel Car & Foundry Company, Chicago, Ill.
Western Tool & Manufacturing Company, Springfield, Ohio.
Westinghouse Air-Brake Company, Pittsburgh, Pa.
Westinghouse Automatic Air & Steam Coupler Company, St. Louis, Mo.
Westinghouse Electric Manufacturing Company, Pittsburgh, Pa.
Westinghouse Machine Company, The, Pittsburgh, Pa.
Wheel Truing Brake Shoe Company, Detroit, Mich.
Wood, Guilford S., Chicago, Ill.
Wood Locomotive Fire Box & Tube Plate Company, W. H., Media, Pa.
Wright Safety Air Brake Company, Greensboro, N. C.
Yale & Towne Manufacturing Company, New York, N. Y.

MIKADO TYPE LOCOMOTIVE

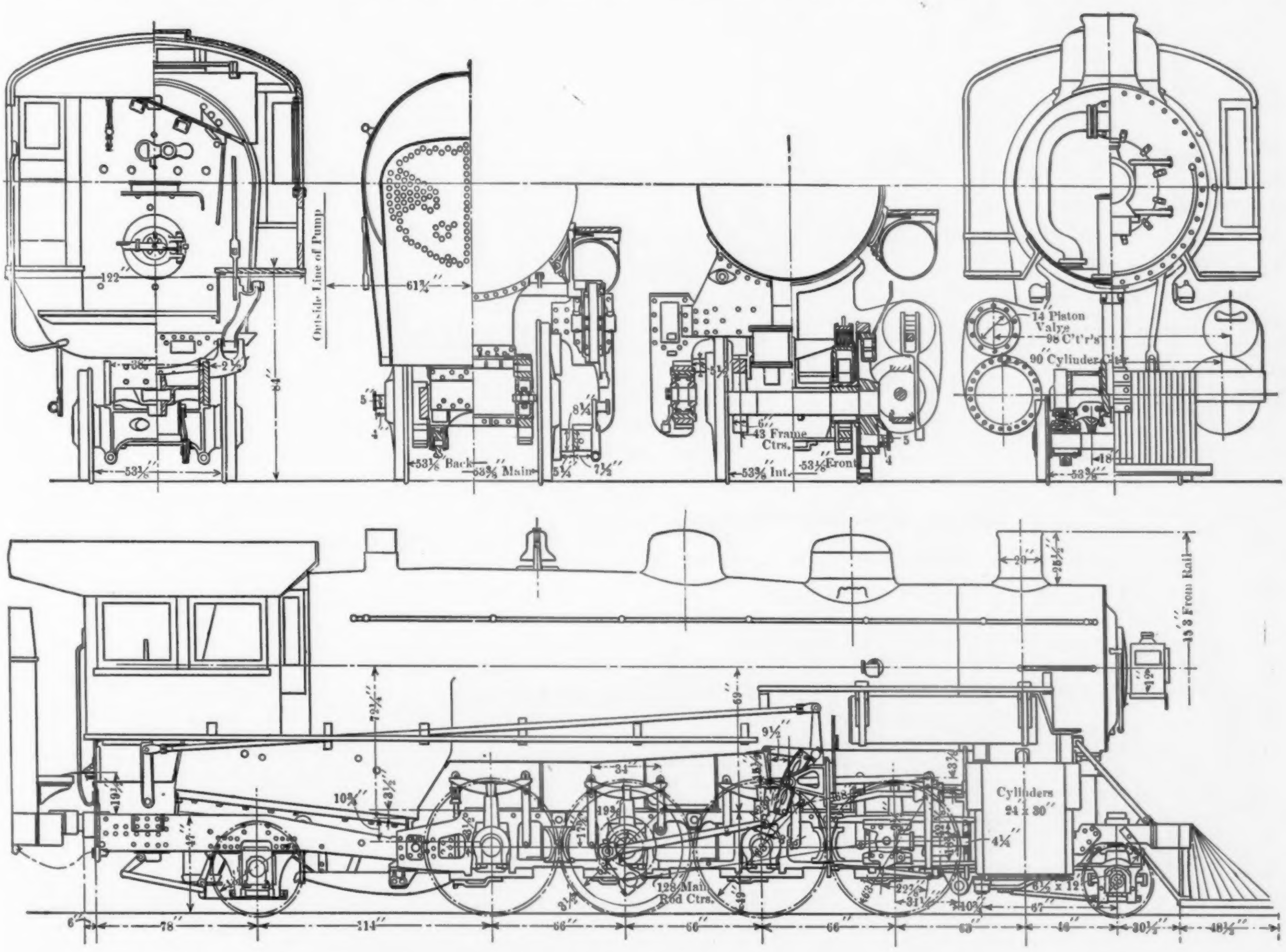
CHICAGO, MILWAUKEE & PUGET SOUND RAILWAY.

For use on its new line from the Missouri River to Puget Sound, the main line of which was recently completed, the Chicago, Milwaukee & St. Paul Railway is building in its shops at West Milwaukee, 20 Mikado type locomotives, which are constructed from drawings prepared in the mechanical engineer's office. This design is based on a most careful study of the conditions under which the locomotives are to operate and of the latest features of successful locomotive practice and contains nothing of an untried or unproven nature.

These locomotives are intended primarily for mountain service and are designed to handle 1,500-ton trains over all except a few of the heaviest grades. There are some 2 per cent. grades on this line on which two of these locomotives, or one with a pusher, will be required to handle this tonnage. Trains of 1,500 tons are brought to the foot of the mountains by Prairie type locomotives having 21 x 28 in. cylinders, 63 in. drivers and weighing 206,000 lbs., of which 142,000 is on drivers. The heaviest grade to the foot of the mountains is one-half to one per cent., which the Prairie type engines will negotiate with ease. The first locomotive of the Mikado type has been in service for two months and has proven itself capable of doing all that was expected of it. They have also shown that in cases of emergency they will be able to handle passenger trains over the mountains at almost schedule speed.

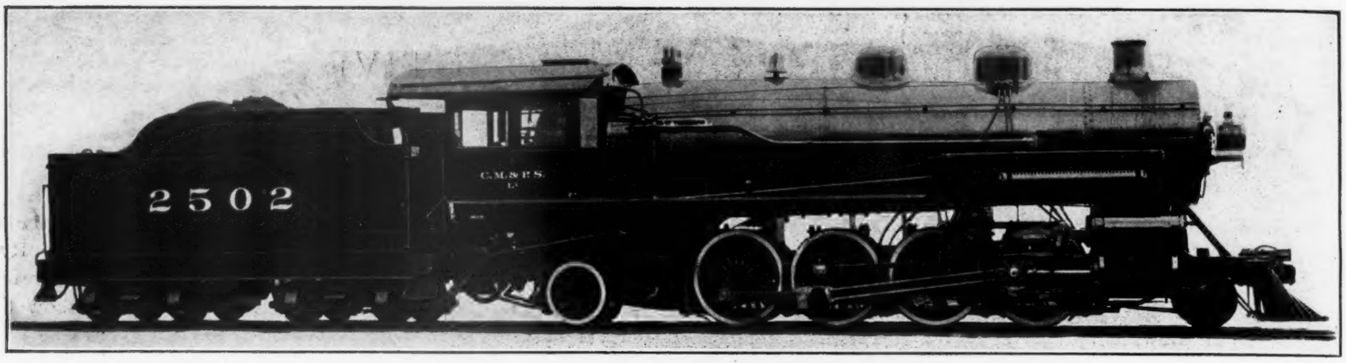
As far as power, size and weight are concerned these locomotives are practically duplicates of the same type of engine in service in a very similar region on the Northern Pacific Ry.* The design throughout is conservative and normal and a reference to the illustrations and tables of dimensions will show the general features.

The point of greatest interest is the boiler, which differs in a number of details from designs on most other railways, although it is very similar to former arrangements on this road. It incorporates a 3 ft. combustion chamber, which several years experience has shown to be a decidedly good thing for service of this character, and has 366 2-in. tubes set about 2⅞ in. centers. The tubes, 17 ft. 6 1/16 in. in length over tube sheets, give 3,332 sq. ft. heating surface. The illustration shows the scheme of locating the tubes for using the area available to the best advantage. The combustion chamber has a water space of about 8 in. at the bottom which narrows somewhat at the sides. The throat of the firebox is 28½ in. in depth to the bottom of the mud ring, a practice which was started on this road a number of years ago and has been consistently followed since. The firebox is radially stayed, there being five rows of sling stays near the front of the crown sheet, no crown bars, however, being used. Four 2-in. combustion flues, two on either side, are located in the side water legs just above the normal fire



MIKADO TYPE LOCOMOTIVE, CHICAGO, MILWAUKEE & PUGET SOUND RAILWAY.

* See AMERICAN ENGINEER, 1905, page 5, and 1906, page 392.



MIKADO TYPE LOCOMOTIVE FOR MOUNTAIN SERVICE.

level for air admission to improve combustion. The location of the dome on the second or central barrel sheet places it out of the range of the greatest ebullition and will doubtless give drier steam than if it was located further back.

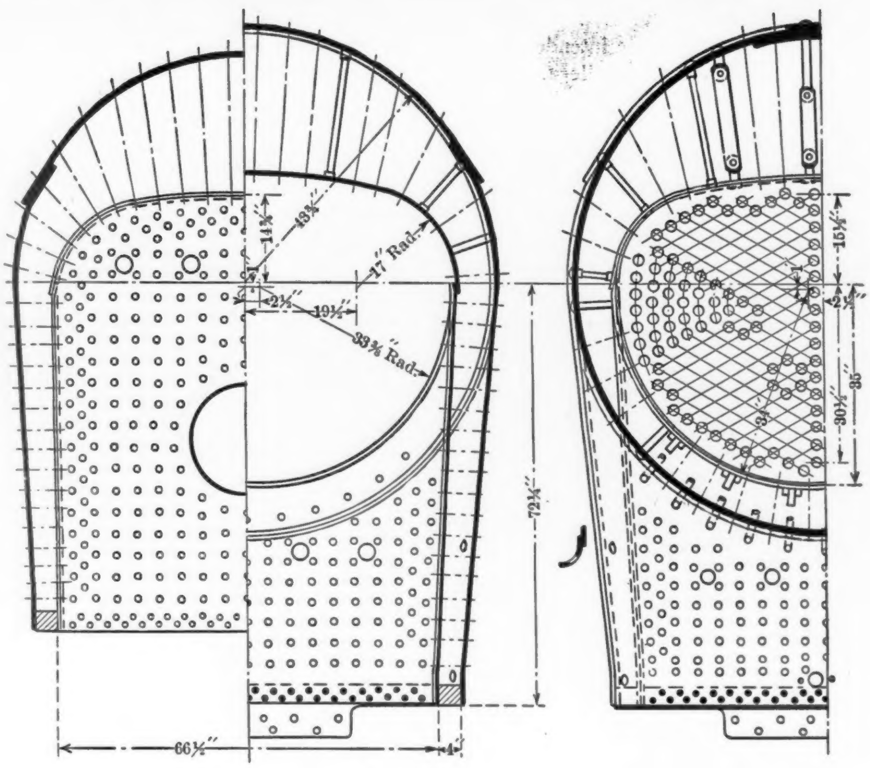
The DeVoy type of trailer truck, which it will be remembered was used on the Vauclain compound Atlantic type locomotives, built by the Baldwin Locomotive Works for this road, and illustrated on page 115 of the March, 1909, issue of this journal, is used in this design. This truck was fully illustrated and described on page 135 of the April, 1905, issue. It is probably the simplest design of trailer truck now in successful use.

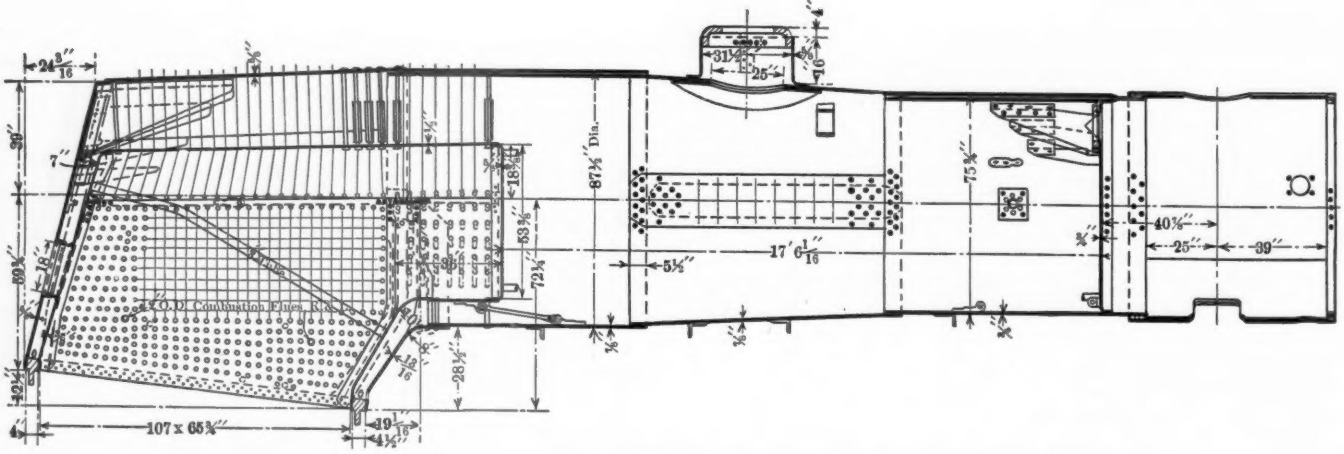
The design of these locomotives was prepared by J. F. DeVoy, mechanical engineer, under the direction of A. E. Manchester, superintendent of motive power.

The general dimensions, weights and ratios are given in the following table:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. Coal
Tractive effort	46,630 lbs.
Weight in working order	260,500 lbs.
Weight on drivers	201,000 lbs.
Weight on leading truck	25,500 lbs.
Weight on trailing truck	34,000 lbs.
Weight of engine and tender in working order	414,500 lbs.
Wheel base, driving	16 ft. 6 in.
Wheel base, total	35 ft. 1 in.
Wheel base, engine and tender	65 ft. 7¼ in.





BOILER, 2-8-2 TYPE LOCOMOTIVE, CHICAGO, MILWAUKEE & PUGET SOUND RAILWAY.

RATIOS.

Weight on drivers ÷ tractive effort	4.31
Total weight ÷ tractive effort	5.80
Tractive effort × diam. drivers ÷ heating surface	812.80
Total heating surface ÷ grate area	74.00
Firebox heating surface ÷ total heating surface, %	7.80
Weight on drivers ÷ total heating surface	55.63
Total weight ÷ total heating surface	72.31
Volume both cylinders, cu. ft	15.70
Total heating surface ÷ vol. cylinders	230.19
Grate area ÷ vol. cylinders	3.10

CYLINDERS.

Kind	Simple
Diameter and stroke	24 x 30 in.

VALVES.

Kind	Piston
Diameter	14 in.
Greatest travel	6¼ in.
Outside lap	1 in.
Inside clearance	0 in.
Lead, constant	¼ in.

WHEELS.

Driving, diameter over tires	63 in.
Driving journals, main, diameter and length	10 x 12 in.
Driving journals, others, diameter and length	9½ x 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	6½ x 12 in.
Trailing truck wheels, diameter	43 in.
Trailing truck, journals	8½ x 14 in.

BOILER.

Style	E. W. T.
Working pressure	200 lbs.
Outside diameter of first ring	75¾ in.
Firebox, length and width	107 x 65¼ in.
Firebox plates, thickness	⅜ in.
Firebox, water space	4½ and 4 in.
Tubes, number and outside diameter	366—2 in.
Tubes, length	17 ft. 6 1/16 in.
Heating surface, tubes	3,332 sq. ft.
Heating surface, firebox	282 sq. ft.
Heating surface, total	3,614 sq. ft.
Grate area	48.8 sq. ft.
Smokestack, height above rail	15 ft. 3 in.
Center of boiler above rail	118 in.

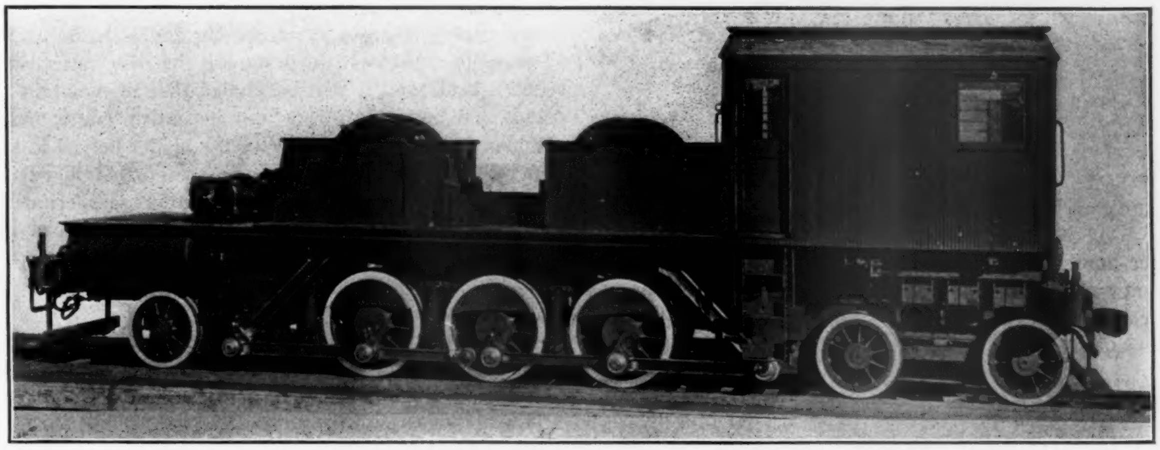
TENDER.

Tank	Water bottom
Wheels, diameter	33 in.
Journals, diameter and length	5½ x 10 in.
Water capacity	8,000 gals.
Coal capacity	14 tons

The motors can also be located so as to concentrate a greater portion of the weight near the center of the locomotive and allow its distribution to be adjusted as desired. It also facilitates inspection and repairs of the motors and the renewal of brushes, and also places them where they are protected from the dirt of the roadbed.

Reference to the line drawing and photograph shown herewith makes clear the general arrangement of the connections between the motors and drivers. In this case the locomotive is of the 4-6-2 type and has two large alternating current motors, mounted on the locomotive frames, within the cab. The frames are of the steam locomotive pedestal type similar to the New York Central design. The shaft of each motor is fitted with a crank at either end, the connection between the armature shaft and crank plate being made through a flexible coupling, which is also illustrated. From the motor cranks the power is transmitted through connecting rods to jack shafts, the bearings of which are secured to the locomotive frame. These shafts have a counter balance weight and are located with their center on a line with the centers of the driving wheels. The cranks on opposite sides are set at 90 degrees. From the pins on the two jack shafts side rods connect directly to the crank pins on the drivers, arranged the same as on a steam locomotive. The object of the jack shafts is to permit a horizontal drive between the spring supported part of the locomotive and the driving wheels, this being necessary in order to allow for the vertical play between the frames and the drivers. The variation in distance between centers of the drivers and jack shafts is negligible. Since there are no reciprocating parts in the machine a perfect balance can be obtained by means of counterbalance weights.

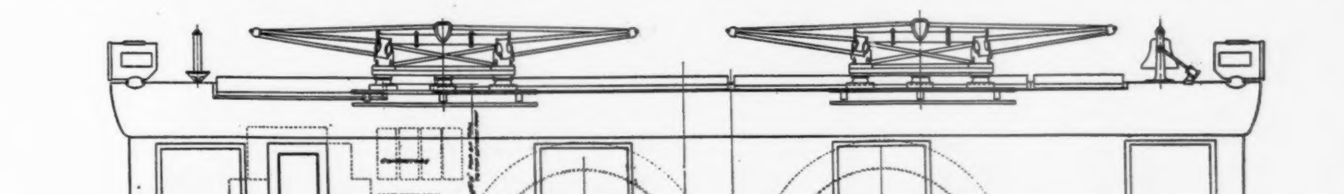
The motors used on this locomotive are arranged to start as



SIDE-ROD ELECTRIC LOCOMOTIVE AS EXPERIMENTALLY EQUIPPED AND HAVING A TEMPORARY CAB.

ELECTRIC LOCOMOTIVE WITH CONNECTING RODS.

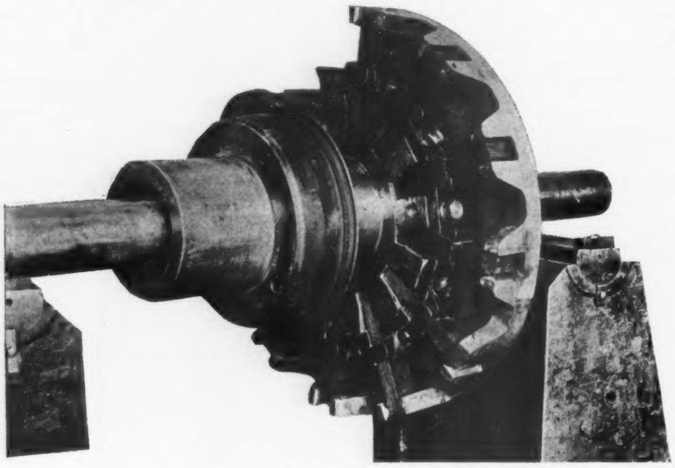
An experimental locomotive has been designed and constructed by the General Electric and American Locomotive Companies for the purpose of trying out a scheme of transmitting power from the motors to the drivers through connecting rods. The advantage of an arrangement of this kind is that motors of large diameter and small air gap can be used in connection with small diameter driving wheels and that the motors can be entirely spring supported. This permits a marked economy in the construction of the motors, as the same horse power can be obtained in two motors at a less cost and with less weight than in four.



SIDE ELEVATION OF SIDE-ROD ELECTRIC LOCOMOTIVE.

repulsion motors with short circuited armature and are changed over to series repulsion motors for the higher speeds. This arrangement eliminates running with a short circuited armature on high voltage and at the same time gives a high torque in starting. This type of locomotive is perfectly adapted for operation with direct current motors as well as with alternating current.

The experimental engine is designed for a tractive effort of 30,000 lbs., at a speed of 18 miles and for a maximum speed of



FLEXIBLE COUPLING BETWEEN MOTOR SHAFT AND CRANK ARM.

50 miles per hour. It has been tried out with temporary motors of somewhat smaller capacity and has successfully demonstrated that the design is entirely satisfactory in every way. The general dimensions of the completed locomotive are as follows:

Weight on drivers	162,000 lbs.
Total weight	250,000 lbs.
Rigid wheel base	10 ft.
Total wheel base	33 ft. 6 in.
Diameter of driving wheels	49 in.
Trolley voltage	10,000
Cycles	15
Horse power, motors, total	1,600

HIGH SPEED MILLING CUTTERS WITH INSERTED BLADES.

The output of the modern high speed milling machine has been restricted by the limited capacity of the inserted blade type of milling cutter, which by reason of its cheapness in first cost and maintenance has been universally adopted for heavy shop milling. Wilfred Lewis and William H. Taylor, in a paper before the December meeting of the American Society of Mechanical Engineers, described a new design of inserted blade cutter which they have recently developed.

Their investigations showed that there was no existing standard, or suitable rule, governing the construction of milling cutters with inserted blades, nor was there any record of exhaustive tests made to determine the most effective pitch, proper clearance angles or front slope and lip angles to be employed. The first point considered in designing the new cutter was the shape of the blade and it was concluded that to maintain a prescribed slope and lip angle throughout its entire length, the blade must be bent to form a helix. With the blades helical in shape, a continuous cutting edge with a constant lip angle would be maintained throughout any length of cutter. Experiments indicated that the most effective angle for the pitch, or lead of the blade, was about 20 degrees. To facilitate computation a formula (diameter $\times$ 9 = pitch) was adopted which gives 19 degs., 15 min. as the angle of the helix.

The grooves in the cutter blank had previously been planed approximately rectangular in section with a slight amount of undercutting to hold the blade and the wedges used for fastening

HIGH POWERED MILLING MACHINE, BEMENT-MILES.

it in place. It was thought, however, that this grooving of the cutter blank could be done better and faster by milling than by planing, and that an undercut groove might be produced at once by a saw set in a certain relation to the cutter blank. This proved practicable, and although the groove so formed was not so easily fitted with a cutter blade on account of its curved sides, the curved sides gave the cutter a lip angle which was of great value in actual service. To form the blades accurately to the shape of the groove, it was necessary to design a bending machine of great power, capable of squeezing the blades at once to

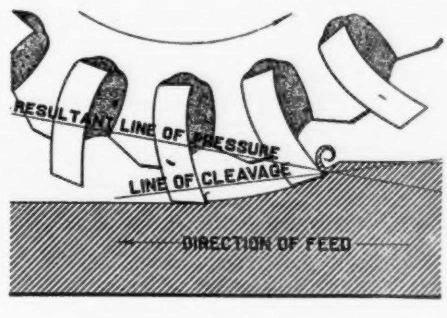


FIG. 4

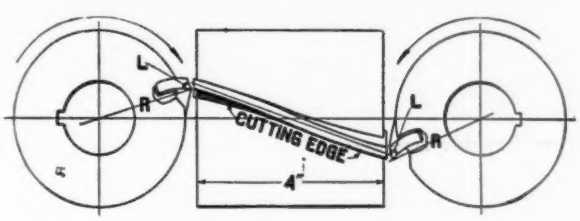


FIG. 5

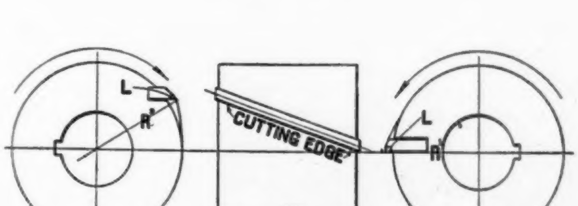


FIG. 6

proper form not only as helices of correct pitch, but of correct curvature in a direction normal to the helix.

Experience had shown that ordinary mechanical fastenings for securing the blades were unsatisfactory, either because of excessive cost or by inability to withstand vibration and remain rigid. Experiments were, therefore, made with various alloys until a proper combination was obtained, capable of flowing freely, of cooling without shrinkage, of withstanding great strains without crumbling, and of permitting quick removal of the blade. A device was designed for compressing the alloy in the slots after it had been poured, and another one for removing the alloy when it was necessary to replace the blades. With the alloy compressed in the slots, the blades are so firmly secured that they may be broken off by force without affecting it.

It is claimed that this construction produces a cutter of moderate diameter and with a greater number of blades for a given diameter than on other cutters of the inserted blade type, and that it has a capacity in excess of the requirements of high powered milling machines.

Fig. 4 shows the form of the slot and blade and the space occupied by the alloy. Fig. 5 shows a constant lip angle, L,

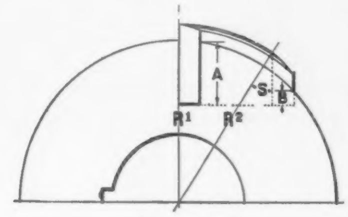


FIG. 7

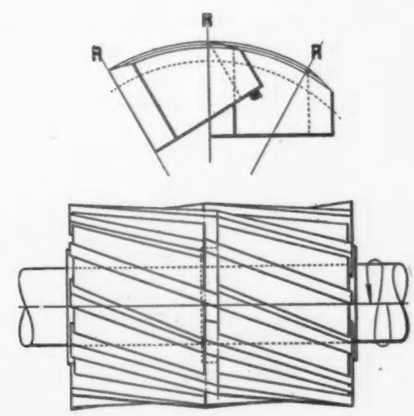


FIG. 8

throughout the entire length of the blade, which is set at an angle of 20 deg. to an axial plane, this angle remaining constant throughout any length by reason of the blade's curvature. Fig. 6 shows a varying lip angle, L, from maximum at line R1 to minimum at line R2, in a straight blade set at an angle of 20 deg. to an axial plane. This condition limits the length of blades. In Fig. 7 a straight blade is set in a plane radiating from the axis, designated by line R1, and by carrying it across the face of the housing at an angle set at 20 deg. to an axial plane. The develop-

TABLE 3.—MILLING CHANNELS, TAYLOR-NEWBOLD HIGH-SPEED STEEL MILLING CUTTER 4⅜-IN. FACE, 8-IN. LISTED DIAMETER, 8½ IN. ACTUAL DIAMETER, 18 IN. INSERTED BLADES, 3½-IN. BORE. TEST MADE AT BEMENT-MILES WORKS, OCTOBER 20, 1908

MACHINE USED: 42-IN. BEMENT-MILES MILLING MACHINE

DRIVING MOTOR: WESTINGHOUSE DIRECT-CURRENT CONSTANT SPEED TYPE 40-H.P. AT 220 VOLTS, 153 AMPERES

MATERIAL CUT: 35 PER CENT. CARBON STEEL FORGING

Cut								Speed of Cutter		Electrical Readings			
Feed				Material Removed						Driving Motor			
Table advance per minute Inches	Advance per blade Inches	Depth Inches	Width Inches	Cubic Inches per minute	Pounds per minute	Pounds per hour	Duration of test	R.p.m.	Feet per minute	Amperes	Volts	H.p.	H.p. per cubic inch removed
								39	82.95	35	220	10.32	
6⅞	.01320	5/16	4⅜	9.40	2.66	159.78	3m. 25s.	37	78.69	85	200	22.74	2.42
1 15/16	.00307	1	4⅜	8.48	2.40	144.14	7m. 12s.	35	74.44	95	185	23.56	2.77
1½	.00231	1	4⅜	6.56	1.86	111.51	4m.	36	76.57	85	193	21.85	3.33
2⅝	.00394	1 5/16	4⅜	15.07	4.27	256.15	2m. 40s.	37	78.69	113	200	30.29	2.00
3⅝	.00544	1 5/16	4⅜	20.81	5.89	353.72	1m. 56s.	37	78.69	135	195	35.28	1.69
5	.00750	1 5/16	4⅜	28.71	8.13	488.01	1m. 24s.	37	78.69	200	190	50.93	1.77

ment from no front slope to a positive front slope is designated by the letter S. In milling, a blade with this irregularity in front slope causes the cutter to drag on one side and gouge on the other. Blades of this type cause excessive vibration to the cutter, due to the varying angle of the front slope, and necessarily consume more power.

Experiments have conclusively demonstrated that nicking the blades of milling cutters does not constitute an altogether desirable feature. The part of the blade behind the nick, which covers the gap formed by the nick in the blade preceding, must take care of double the feed of the remainder of the tooth; this causes chatter and produces an uneven machined surface.

Fig. 8 shows a cutter with straight inserted blades made up in sections, each alternate blade overlapping the blades in the opposite section, so as to obtain the desired width of face. The sections are so set that the cutting edge forms a continuous line. Above the cutter is a diagram showing the relation of the blades in one section to those in the other.

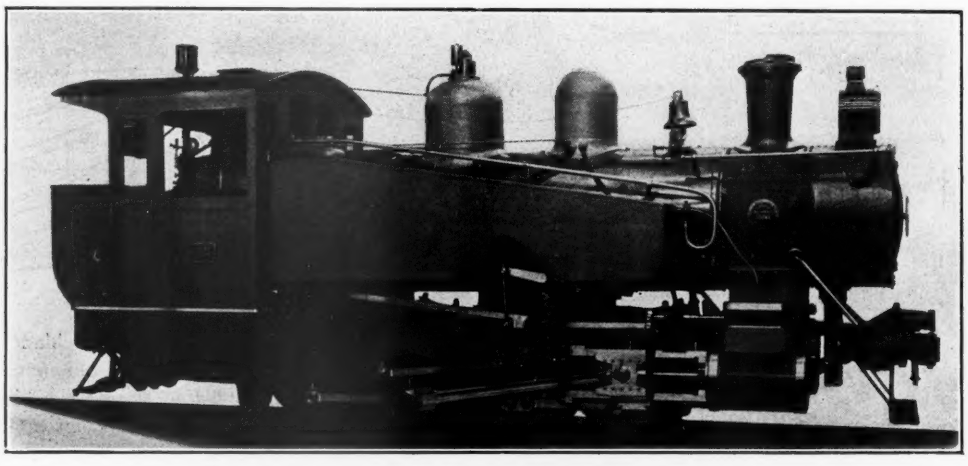
Too much stress cannot be laid on the use of a lubricant during the process of milling. A copious stream of lubricant falling at slow velocity should be thrown directly upon the chip at the point of removal. Heat generated by the pressure of the chip is the chief cause for wear, and if allowed to become too great it will soften the lip surface of the blades and cause them to crumble or spall off. An ample supply of lubricant during the milling operation carries off the heat, materially lessening the dulling of the cutting edges. It has been conclusively shown that a gain of 33 per cent. in the cutting speed in milling steel and wrought iron is made by throwing a heavy stream of lubricant upon the cutter and along its entire face; and a gain of 15 per cent. in milling cast iron.

The accompanying table shows the results of a test made with these cutters. The material cut was 35 per cent. carbon steel. The tests were made on a 42 inch Bement-Miles milling machine driven by a Westinghouse direct-current, constant speed, 40 horse power motor.

EIGHT WHEEL SWITCHING LOCOMOTIVE.

WESTERN RAILWAY OF HAVANA.

As an example of a very compact source of tractive effort the switching locomotive, shown in the illustration, and recently completed by the Baldwin Locomotive Works for the Western Railway of Havana, Ltd., is very interesting. It provides a tractive effort of practically 32,000 lbs. in a machine which occupies but little over 33 ft. of total track space and is carried on a wheel base of less than 12 ft., with a pressure on the rail of about 16,520 lbs. for each wheel. This gives a locomotive that is capable of going into all kinds of odd corners over poorly ballasted track and able to handle a good load even on a stiff grade under those conditions. As can be seen, it is of the tank type, an arrangement which for a switching locomotive has many advantages and, under the special conditions that such a design would operate, very few disadvantages.



SWITCHING LOCOMOTIVE, WESTERN RAILWAY OF HAVANA.

The details of construction are markedly simple throughout. The Walschaert valve gear, with a slide valve, has been employed, an arrangement having been designed which is exceptionally free from complications and of very few parts. The valves are set with a constant lead of 3/16 of an inch. It was necessary to cut away the bottom of the side tanks to clear the lift shaft arms, but a suitable arrangement of equalizing pipes has been fitted to keep the water level the same in all parts of both tanks.

The boiler is of the Belpaire type, with an extension front end. An interesting detail in boiler design is found in the shape of two equalizing stays, which it was necessary to arrange in the transverse staying above the crown sheet in order to clear the longitudinal stays from the back head. This construction is shown in detail in one of the illustrations.

In other respects the details of the boiler and running gear are not unusual. Parts, as far as possible, have been made interchangeable with those on previous engines for the same road, many of which were built by these works.

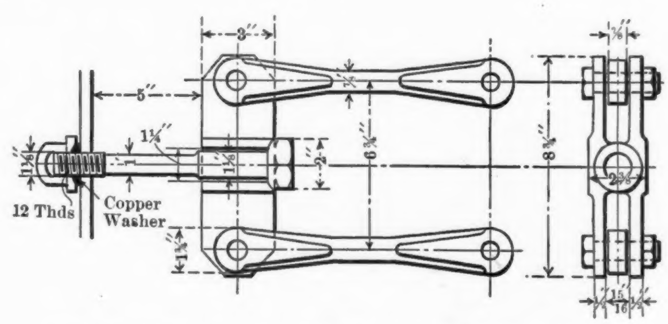
The general dimensions, weights and ratios are given in the following table:

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Switching
Fuel	Coal
Tractive effort	31,930 lbs.
Weight in working order	130,000 lbs.
Weight on drivers	130,000 lbs.
Wheel base, driving	11 ft. 9½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.07
Total weight ÷ tractive effort	4.07
Tractive effort × diam. drivers ÷ heating surface	980.00
Total heating surface ÷ grate area	61.60
Firebox heating surface ÷ total heating surface, per cent	7.80
Weight on drivers ÷ total heating surface	87.00



ARRANGEMENT OF STAYS ABOVE CROWN SHEET TO CLEAR LONGITUDINAL STAYS.

Volume both cylinders, cu. ft	8.70
Total heating surface ÷ vol. cylinders	172.00
Grate area ÷ vol. cylinders	2.78

CYLINDERS.

Kind	Simple
Diameter and stroke	20 x 24 in.

VALVES.	
Kind	Slide
Kind of Gear	Walschaert
Lead, constant	3/16 in.
WHEELS.	
Driving, diameter over tires	46 in.
Driving, thickness of tires	3 in.
Driving journals, diameter and length	8 x 9 in.
BOILER.	
Style	Belpaire
Working pressure	180 lbs.
Outside diameter of first ring	56 in.
Firebox, length and width	84 1/16 x 42⅞ in.
Firebox plates, thickness	5/16, C—⅜, T—½ in.
Firebox, water space	F—4, S & B—3 in.
Tubes, number and outside diameter	180—2¼ in.
Tubes, length	13 ft. 1 in.
Heating surface, tubes	1,378 sq. ft.
Heating surface, firebox	116 sq. ft.
Heating surface, total	1,494 sq. ft.
Grate area	24.2 sq. ft.
Smokestack, diameter	14 in.
Center of boiler above rail	88½ in.
Tank	2 Side Tanks
Water capacity	1,500 gals.
Coal capacity	65 cu. ft.

THE SHOP SURGEON.

The shop surgeon is an important member of the official staff at the Collinwood shops of the Lake Shore & Michigan Southern Railway. In addition to the two thousand men employed in the locomotive and car shops there are about two hundred and sixty-five employees at the Collinwood engine house. The following information concerning the work of the shop surgeon is taken from a paper on "The Locomotive Shop and Its Proper Organization" presented by M. D. Franey, superintendent of the Collinwood shops, before a recent meeting of The Cleveland Engineering Society.

In the month of January, 1908, the office of shop surgeon was established in the main office building at Collinwood shops. Previous to this time the shop surgeon was located in the Village of Collinwood, about half a mile from the shop, which location was more convenient than that of the average shop surgeon. The results obtained from this change have been so satisfactory, morally and financially, that this department is now considered a very essential part of the organization.

It is a well-known fact that where accident cases can receive immediate attention from the surgeon, chances for infection that might exist in a dirty shop wound, are in a great measure eliminated; it also insures prompt returning to the shop of skilled workmen, their services and the output of valuable machines, otherwise non-productive due to the operators' absence. It is also true that if an employee is sent out of the shop grounds to a doctor's office, unavoidable delays are caused owing to waiting the regular turn in the office. A careful daily record is maintained by the surgeon of the condition of each patient during treatment and on discharge, thus providing permanent information of value from a legal standpoint.

Loss to the company due to blood poisoning is avoided by correct early treatment. The surgeon ascertains from each individual after an accident whether he has any suggestions as to how similar accidents may be avoided in the future. In addition to this, the surgeon visits the scene of each accident and makes recommendations to the proper authority for the removal of the cause. He makes a close study of safety appliance laws, and inspects and criticises the plant with a view of complying with these laws. On these inspection trips, sanitary conditions are criticised and corrected. The surgeon formulates laws regulating the workman's presence at the plant if contageous diseases exist in the household. Suspicious cases of chronic individualism are reported to the surgeon, who makes proper decision as to the disposition of each case, particularly in tubercular cases.

A part of this organization consists of a systemized call for assistance in case of wreck or unusual accidents. On the shop surgeon's desk is a carefully prepared list of doctors in the order of their proximity to the plant, and the same information is recorded for ambulance and hospital calls. This department aids and maintains discipline by quickly and gently removing to the operating room, all injured individuals thus avoiding the depressing influence of gruesome sights. It is of great assistance to the organization, as the men feel that the surgeon is there for their protection and appreciate the services rendered by him. It also aids the claim department by furnishing them promptly with information, and by courtesy and tact, allaying the first feeling of resentment on the part of the injured.

All road men and apprentices are examined for physical fitness, color blindness, visual defects and hearing. Periodical lectures are given to apprentices and employees with proper instructions on "First Aid to the Injured."

INSPECTION ON THE HARRIMAN LINES.

The adoption of standards implies seeing that they are maintained. Each general manager and the members of his staff may in the utmost good faith report that a standard practice or device has been installed. Investigation may disclose the fact that due to honest differences in interpretation two adjacent properties have in reality widely varying practices. Such non-standard conditions can only be ascertained and corrected by open and above board inspection from the Chicago office.

The director of maintenance and operation and the members of his personal staff spend much of their time on the road, seldom traveling together, and seldom all being in Chicago at once. They cannot, however, do all of the inspecting necessary for proper co-ordination. To avoid dwarfing the general managers by building up a large permanent staff in Chicago, the condition is met by detailing for temporary special duty as inspectors or special representatives various officials of the Associated Lines. This serves a double purpose. It secures not only proper information of actual conditions for the Chicago office, but it broadens the individual selected. He returns to his own property with the viewpoint of the Chicago office, some knowledge of the other properties, and a better appreciation of the problems of correlation. During his absence, an understudy in his own position has been tried out for future advancement. The effort is to develop all-around men. For example, a general superintendent was detailed to act as chairman of a committee which traveled over the Associated Lines and other railways to recommend the best practices in handling brakes on heavy grades. In addition to a valuable report on this subject he also, among other things, made useful recommendations as to standardization of trainmen's uniforms.

The effort is to use intelligent, high class inspection as a means of disseminating education to officials. The financial depression of 1907 caused drastic reductions in maintenance expenses. To make certain that the point of safety was not passed, and to assist in meeting the exceptional state of affairs, a maintenance of way inspector traveled over the lines for several months conferring freely with local officials. When it became manifest that the desired result had been reached, this inspection work was discontinued. Frequently, a prescribed report can be made to answer certain purposes of inspection without sending out an inspector. When the effect has been produced, when the lesson has been learned, the report is withdrawn. Examples of current reports to the Chicago office which have been discontinued are, cast iron wheels removed per 100,000 car miles run; hot boxes per 100,000 car miles run; engine failures; comparative cost of repairs as between steel and wooden cars.

The inspectors and special representatives are forbidden to exercise authority. They can observe, inquire, investigate, confer, advise, suggest and report, but must not order or interfere with local administration.—*J. Kruttschnitt before the New York Railroad Club.*

THE SUPPLYMAN.—He keeps in touch with all the best things in the market; and after we get so we know and trust him, he is really a great help to us; he keeps us posted as to what is going on, what the other fellow is doing, how he does it, what economies he makes in operation or maintenance, and thus enables us to get into the game and handle our business with greater efficiency and more economic results.—*A. W. Martin, New England Railroad Club.*